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NASA

APPLICATION TEAM PROGRAM

(NASA-CR-144919) APPLICATIONS OF AEROSPACE TECHNOLOGY IN BIOLOGY AND MEDICINE Final Report, Sep. 1974 - Aug. 1975 (Research Triangle Inst., Research Triangle) 92 p HC $5.00 CSCL 06E G3/52
N76-13736
Unclas
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Applications of Aerospace Technology in Biology and Medicine

final report

september 1974 – august 1975

RESEARCH TRIANGLE INSTITUTE
RESEARCH TRIANGLE PARK, NORTH CAROLINA

PREFACE

This report covers the medically related activities of the NASA Application Team Program at the Research Triangle Institute between September 1, 1974, and August 31, 1975, performed in the Center for Technology Applications of the Research Triangle Institute under the technical direction of Dr. J. N. Brown; Director, Center for Technology Applications and Acting Director, Biomedical Application Team. Dr. H. C. Beall has performed the duties of Team Director for approximately two months and will become Director of the RTI Biomedical Applications Team on September 1, 1975. Full-time members of the Team who participated in the project are Dr. H. C. Beall, Mr. J. C. Ruddle, Mr. R. W. Scearce, and Ms. S. K. Commee. Assistance from other members of the RTI staff was obtained as needed.

Medical consultants who contributed to the project are Dr. E. A. Johnson, Duke University Medical Center, Durham, North Carolina; Mr. William Z. Penland, National Cancer Institute, Bethesda, Maryland; Professor Hal C. Becker, Tulane University School of Medicine, New Orleans, Louisiana; Dr. Jacob Kline, University of Miami School of Medicine, Miami, Florida; and Mr. Edward Wallerstein, Mount Sinai Medical Center, New York, New York.

The RTI Biomedical Application Team is funded by NASA Contract NASW-2729. Technical responsibility and contract administration were transferred from NASA Headquarters to NASA Langley Research Center on January 24, 1975. The Technical Monitor is Mr. John Samos, Programs Officer, Technology Utilization Office, Langley Research Center.

For the convenience of the reader, the names and addresses of the sources of certain commercial products are included in this report. This listing does not constitute an endorsement by either the National Aeronautics and Space Administration or the Research Triangle Institute.

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ABSTRACT

This report presents the results of the medically related activities of the NASA Application Team Program at the Research Triangle Institute. This experimental program in technology application was supported by NASA Contract No. NASW-2779 for the reporting period September 1, 1974, to August 31, 1975. The RTI Team is a multidisciplinary team of scientists and engineers acting as an information and technology interface between NASA and individuals, institutions, and agencies involved in biomedical research and clinical medicine. During the reporting period, participants in the Application Team Program included Dr. J. N. Brown, Jr., Electrical Engineer; Mr. R. W. Scearce, Biomedical Engineer; and Ms. S. K. Commee. In addition, the Team draws upon the capabilities of other members of the RTI staff as needed.

Nineteen medical organizations are presently participating in the RTI Application Team Program: Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina; Duke University Medical Center, Durham, North Carolina; Emory University School of Medicne, Atlanta, Georgia; Hahnemann Medical College, Philadelphia, Pennsylvania; Illinois Pediatric Institute, Chicago, Illinois; Institute for Cancer Research, Philadelphia, Pennsylvania; Jefferson Medical College, Philadelphia, Pennsylvania; Johns Hopkins University Medical School, Baltimore, Maryland; National Heart and Lung Institute, Bethesda, Maryland; Tulane University School of Medicine, New Orleans, Louisiana; University of Miami School of Medicine; Miami Florida; University of Mississippi Medical Center, Jackson, Mississippi; Universtiy of North Carolina; Veterans Administration Hospital, Oteen, North Carolina; and Virginia Department of Vocational Rehabilitation, Fishersville, Virginia.

The accomplishments of the Research Triangle Institute Application Team during the reporting period are as follows: The Team has identified 40 new problems for investigation, has accomplished 5 technology applications, 9 potential technology applications, 3 impacts, has closed 27 old problems, and on August 31, 1975, has a total of 57 problems under active investigation.

In addition to the above numerical objectives, the Team has accomplished several general objectives during the contract year. First, a survey of more than 300 major medical device manufacturers has been initiated for the purpose of determining their interest and opinions in regard to participating in the NASA Technology Utilization Program. Second, the Team has commissioned the design and construction of a permanent exhibit of NASA Biomedical Application Team accomplishments for the aerospace building of the North Carolina Museum of Life and Science at Durham, North Carolina. Third, the Team has initiated an expansion of its activities into the Northeastern United States. Fourth, the Team continues its activities with the Aerospace Technology Committee of the Association for the Advancement of Medical Instrumentation.

1.0 PROGRAM PHILOSOPHY AND METHODOLOGY

1.1 Introductory Comments

The National Aeronautics and Space Administration (NASA) has been a leader and innovator in the establishment, operation, and assessment of technology transfer programs since that agency was established by the Space Act of 1958. Through its Tech Brief, Special Publication, Technology Survey, and Regional Dissemination Center programs, NASA has been successful in transferring the results of aerospace research to an impressive number of nonaerospace applications.

In 1966, NASA established a Technology Utilization program using an active and directed methodology. In this program, Application Teams were established under contract to the NASA Technology Utilization Office. The Application Team methodology is active in that specific problems are identified and specified through direct contact with potential users of aerospace technology. The process is directed, for the team interacts only with the potential users who are involved in reaching selected national goals. Four Teams specializing in biomedicine have been established at the following institutions:

Research Triangle Institute
Post Office Box 12194
Research Triangle Park, North Carolina 27709

Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78228

Stanford University School of Medicine
701 Welch Road
Palo Alto, California 94304

University of Wisconsin
1500 Johnson Drive
Madison, Wisconsin 53706

This report covers the accomplishments and activites of the Team located at the Research Triangle Institute for the period September 1, 1974, to August 31, 1975. In the remainder of Section 1.0, Team objectives and methodology are presented.

1.2 Biomedical Application Team Program

The NASA Biomedical Application Team Program specifically seeks to achieve the following goals:

(a) The identification of relevant aerospace technology that can solve major medical problems;

(b) The utilization of the identified technology in order to actually solve the existing medical problems; and

(c) The motivation of members of the industrial community to manufacture technology resulting from this program in order that widest possible use of the technology can be achieved.

Basically, the Team acts as an active interface between medical investigators and the body of scientific and technical knowledge that has resulted from the U.S.A. aerospace research program. The Team attempts to carefully define specific technological problems facing the medical community and to identify the relevant aerospace technology that can solve those problems. The problems are those encountered in medical research programs in major medical schools and in the National Institutes of Health. The Team actively engages in the identification of these problems through direct contacts with the medical research staffs. The identification and specification of the medical problems are then followed by search for technology that can be utilized in solution of the problems.

Generally, the technology relevant to the solution of a specific technological problem in the medical field is identified through three approaches: (1) manual and computer searching of the aerospace information bank created by NASA as part of its R&D efforts, (2) direct contact with the engineering and scientific staff at NASA Field Centers, and (3) circulation of concise problem statements to a large number of NASA scientists and engineers. Technology representing potential solutions to problems is channeled through the Team to the problem originator for his evaluation and implementation. Alternatively, the Team establishes a contact between the problem originator and NASA Field Center personnel, and the transfer of information between NASA and the problem originator becomes more direct.

Assistance to the problem originator in implementing solutions to problems is an important part of the Application Team Program. This assistance may take any one of a number of different forms. Direct assistance to the problem originator in his efforts to implement a solution is frequently involved. During this reporting period, NASA's Office of Technology Utilization has utilized reengineering or adaptive engineering capabilities of various NASA centers in those cases where feasibility had been demonstrated. The Teams are responsible for identifying the NASA technology that is potentially a solution to a specific problem and for specifying the changes required in this technology. The NASA adaptive engineering activity allows the Teams to demonstrate that the technology is in fact a solution to the problem and, in many cases, allows the problem originator to make use of the NASA technology in his research that might otherwise be impossible.

The successful transfer of information on aerospace technology to an individual or group in the medical field followed by successful implementation of the technology is called a "technology application." Also included in the definition of technology application is the constraint that the medical application and objective involved in the technology application be different from the aerospace application and objective for which the technology was originally developed. Thus, the accomplishment of technology applications is indeed a difficult and long-term objective. This objective should be distinguished from that involved in a program to enhance the diffusion or broad utilization of demonstrated applications of technology.

A specific methodology is applied by the Team in its efforts to effect applications of aerospace-related technology. This methodology is discussed in the following section.

1.3 Methodology

The methodology used by the Team consists of six basic steps: problem definition, identification of relevant technology, evaluation of relevant technology, utilization of technology, identification of an appropriate manufacturer, and documentation. This methodology can be better understood, however, if it is separated into the steps shown in figure 1. These steps are described in the following paragraphs.

Problem Screening - Effective problem screening is at least as important to the success of the Application Team Program as any of the operational steps identified in Figure 1. Analysis of the RTI Team's accomplishments in the early days of the program indicates clearly that a very significant fraction of the problems that were unsuccessfully investigated could have been rejected very early in discussions with problem originators. Problem selection criteria have since been developed for the purpose of increasing the probability that a technology application can be accomplished for those problems accepted by the Team. At the present,the following criteria are being applied:

(a) Solving the problem would enhance medical diagnosis, treatment, or patient care to the extent that implementation and adoption would be rapid,

OR

(b) The problem has been encountered in an ongoing research program and is impeding progress of that program,

OR

(c) Some unique characteristics of the problem or the problem originator indicates that investigating the problem will enhance the overall Team program,

AND

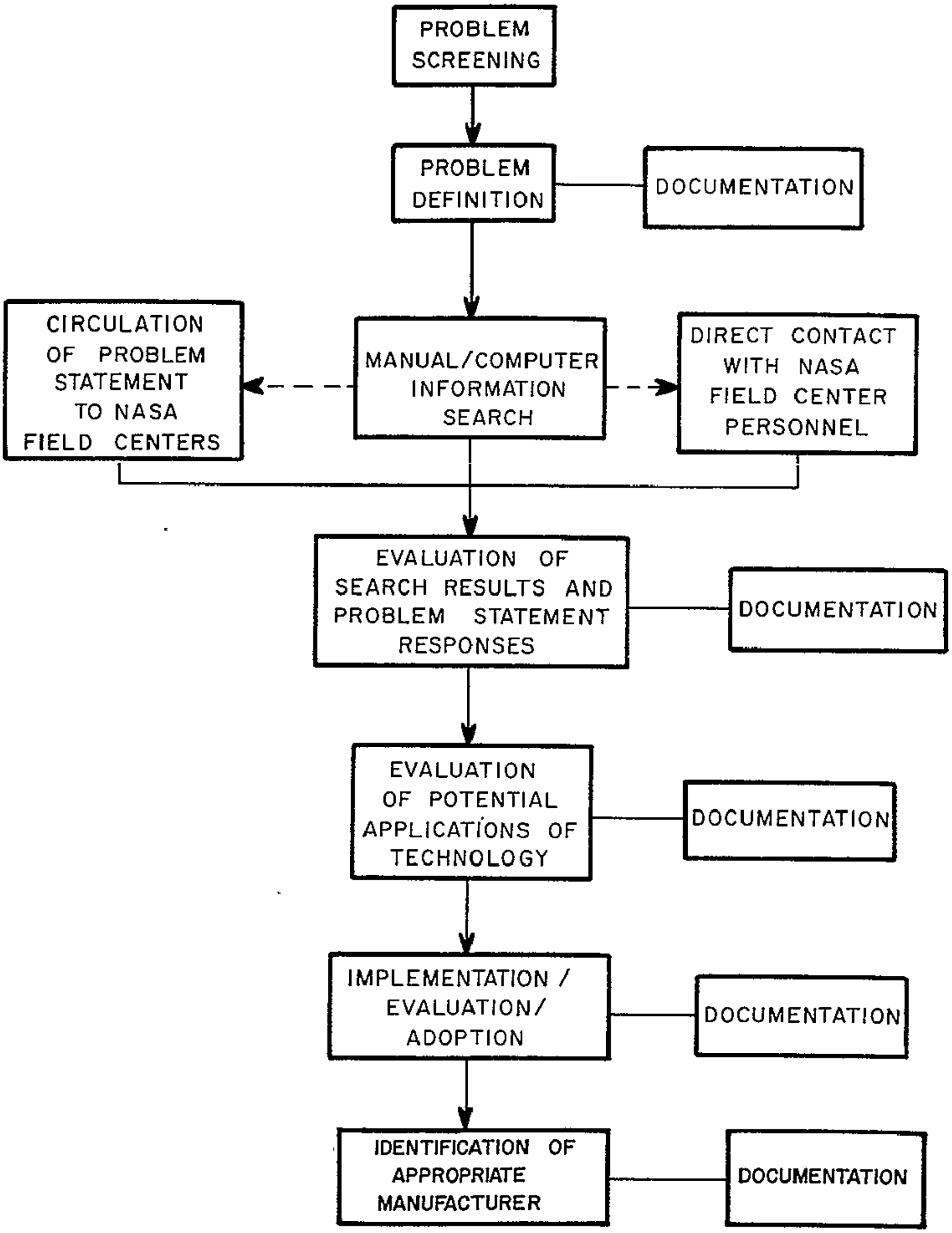

Figure 1. Flow Chart of Application Team Transfer Methodology.

(d) Solving the problem is given high priority by the problem originator,

AND

(e) The problem is one of *at most* two being investigated with an individual problem originator. (This is violated only in the case of large group efforts.)

Problems that do not satisfy these criteria are rejected. Problems may also be rejected following partial completion of the next step, problem definition.

Problem Definition - The objective of this step is to define precisely and accurately the characteristics of the technology required to solve a problem. In many cases, following the characterization of required technology, it is found that the problem should be rejected or closed for any of a number of reasons. These reasons include, as examples, the following: (1) the problem can be solved using commercially available equipment; (2) the real problem is medical and not technical in nature; and (3) the requirements cannot be specified because insufficient information exists on the objective involved.

The end result of problem definition is the preparation of a problem statement. This statement, to be complete, must contain (1) a complete characterization of what is required to solve the problem, and (2) the related medical problem or objective and the benefits to be realized by solving the problem.

Identification of Relevant Aerospace Technology - Aerospace technology that may be relevant to the solution of a problem is identified by three approaches. First, a manual or computer search is made of the aerospace information bank. These searches are made at one of NASA's six Industrial Applications Centers (IAC's). The IAC used by the RTI Team is the North Carolina Science and Technology Research Center (NCSTRC) located in Research Triangle Park, North Carolina. In addition, literature searches are made utilizing the NASA Scientific and Technical Information Facility in College Park, Maryland. The information that can be assessed through the information bank consists of approximately 775,000 documents, articles, and translations that have been abstracted in the Scientific and Technical Aeropsace Reports (STAR) and the International Aerospace Abstracts (IAA). Second, the Team contacts individuals at the Field Centers directly without circulating problem statements. This is done when a Team member can identify a relatively few individuals at the Field Centers who are likely to have a good overview of all work being done that is related to the requirements of a specific problem. Third, problem statements are circulated to engineers and scientists at NASA Field Centers who may be able to identify relevant technology and suggest possible solutions to problems. These statements are circulated in a highly selective manner with the distribution being determined by the Team, Technology Utilizations Officers (TUO's) at the NASA Field Centers, and other individuals at the Field Centers.

Evaluation - All potentially relevant technology identified in the preceding step is evaluated by the Team to determine whether a potential solution to a specific problem has been found. Those items of technology that represent potential solutions to problems are presented to problem originators along with available supporting data and information. Any required reengineering and the details of implementing the potential solutions are discussed with the problem originator.

The problem originator must then evaluate potential solutions. His decision to implement a proposed solution will depend upon a number of factors: (1) his assessment of the validity of the proposed potential solution, (2) the cost of implementing the potential solution, (3) the potential benefits to be gained, etc. The Team may be asked to supply additional information and technical details in this evaluation.

Implementation, Final Evaluation, Adoption - The final step in the technology application process is the implementation and experimental evaluation of potential solutions. This critical phase must occur in order for a technology application to be complete. The Team is available for assistance in this step when required, and attempts to identify the resources necessary to meet the implementation requirements. In many cases, the actual implementation can be carried out by the problem originator and his staff. In some cases, however, skills not immediately available to the problem originator are required for implementation, and, in these cases, some other resource is utilized. This may require the use of a NASA capability at one of the Field Centers or at a NASA contractor. In other cases, the implementation may be carried out by an industrial concern under contract to the problem originator. In general, the Team attempts to determine the most appropriate means of implementation and to make recommendations to the problem originator as required.

Identification of Appropriate Manufacturer - If maximum utilization of technology is to be achieved, then the technology must be available to physicians from a medical device manufacturer. To reach this goal, the Team actively seeks interested manufacturers for appropriate devices. Direct contacts are made to specific manufacturers, and, in addition, liaison with the medical device community is maintained through the Aerospace Technology Committee of the Association for the Advancement of Medical Instrumentation.

Documentation - Documentation is an integral part of the Team methodology; it is involved at most steps in the process, as indicated in Figure 1. Documentation allows analysis of the technology application process and assessment of the program in general. At present, the Teams report on a quarterly schedule. Effective communication is required between Teams, potential problem originators, and other individuals who are in positions to make use of information resulting from technology applications accomplished by the Teams.

1.4 Application Team Composition and Participating Medical Institutions

The RTI Team is a multidisciplinary group of engineers and scientists. The educational backgrounds of the groups are in physics and electrical engineering; their experience includes industry, education, and research at both basic and applied levels. The individuals who have participated in the Application Team Program during this reporting period are:

Name	*Background*	*Responsibility*
Dr. J. N. Brown, Jr.	Electrical Engineer	Laboratory Supervisor
Dr. H. C. Beall	Physiologist	Team Director
Mr. J. C. Ruddle	Biomedical Engineer	Solution Specialist
Mr. R. W. Scearce	Biomedical Engineer	Solution Specialist
Ms. S. K. Commee	Secretary	Documentation

The experience and special capabilities of other individuals at RTI--particularly in the Engineering and Environmental Sciences Division--are frequently used as needed in the Application Team Program.

At present, 19 medical institutions are participating in the RTI Application Team Program. These institutions are as follows:

Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina;

Duke University Medical Center, Durham, North Carolina, (including Veterans Administration Hospital, Durham, North Carolina);

Emory University School of Medicine, Atlanta, Georgia;

Hahnemann Medical College, Philadelphia, Pennsylvania;

Illinois Pediatric Institute, Chicago, Illinois;

Institute for Cancer Research, Philadelphia, Pennsylvania;

Jefferson Medical College, Philadelphia, Pennsylvania;

Johns Hopkins University Medical School, Baltimore, Maryland;

Medical University of South Carolina, Charleston, South Carolina;

Mount Sinai Medical Center, New York, New York;

National Cancer Institute, Bethesda, Maryland;

National Heart and Lung Institute, Bethesda, Maryland;

Tulane University School of Medicine, New Orleans, Louisiana;

University of Miami School of Medicine, Miami, Florida;
(including Veterans Administration Hospital, Miami, Florida);

University of Mississippi Medical Center, Jackson, Mississippi;

University of North Carolina Dental School and Dental Research Center, Chapel Hill, North Carolina;

University of North Carolina School of Medicine, Chapel Hill, North Carolina;

Veterans Administration Hospital, Oteen, North Carolina;

Virginia Department of Vocational Rehabilitation, Fishersville, Virginia.

Figure 2 shows the geographical distribution of the RTI Application Team user institutions as well as the location of the major NASA resources.

The RTI Team is assisted at various stages of the technology application process by consultants who are on the medical staffs at participating institutions. These consultants or communicators coordinate Team activities at their institutions and assist Team members primarily in problem definition and evaluation of potential solutions. At present, the following individuals are consultants to the RTI Team.

Name	*Speciality*
Dr. E. A. Johnson Duke University Medical Center	Cardiac Physiology
Professor Hal C. Becker Tulane University School of Medicine	Radiology
Mr. William Z. Penland National Cancer Institute	Engineering
Dr. Jacob Kline University of Miami School of Medicine	Engineering
Mr. Edward Wallerstein Mount Sinai Medical Center	Engineering

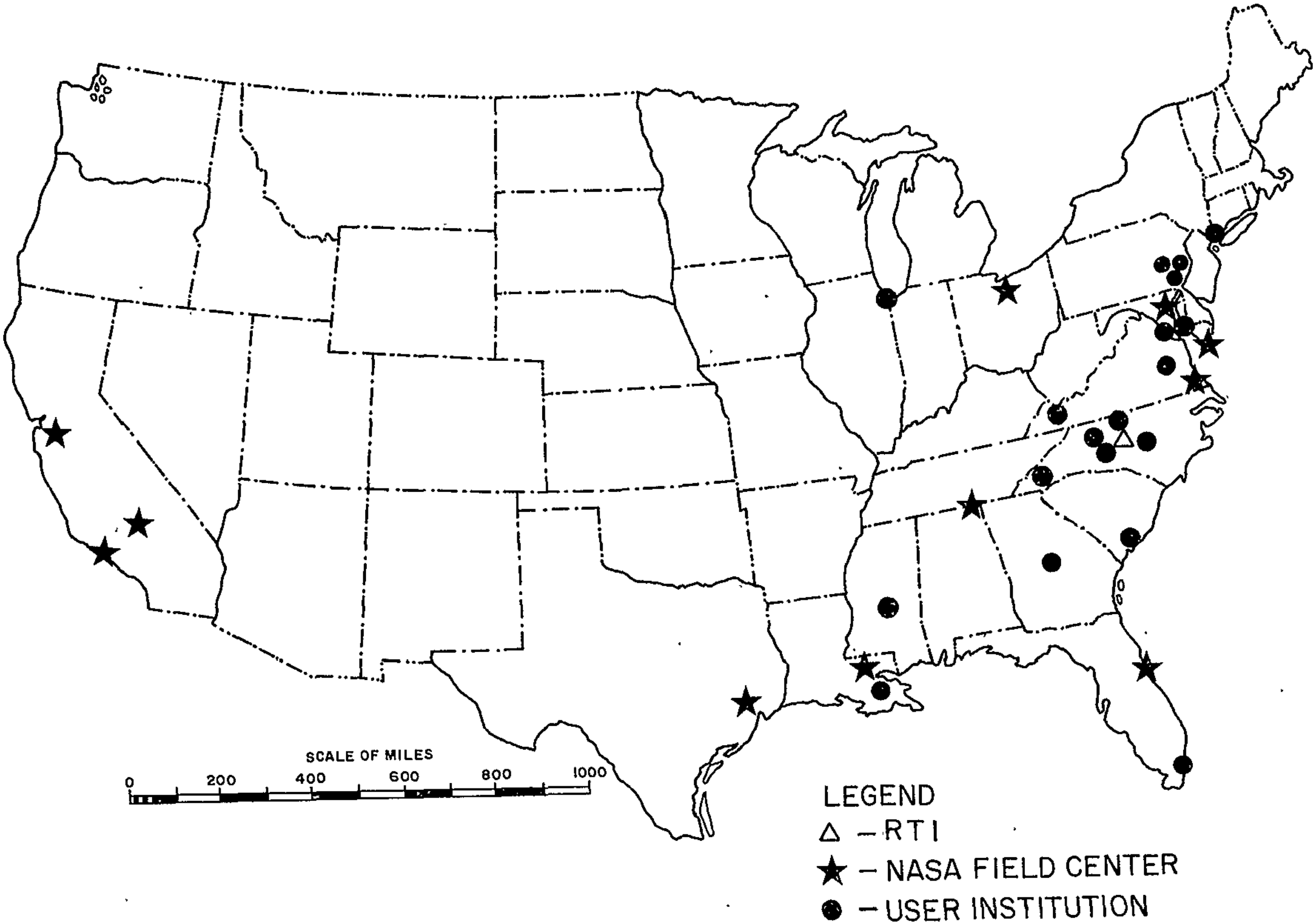

Figure 2. Team Activity Centers in the United States.

Problems at each institution are coded by an alphanumeric symbol (e.g., DU-49); the letter prefix coding for institutions or special problem areas is as follows:

CP	-Computer software-type problem
DU	-Duke University Medical Center
EU	-Emory University School of Medicine
HMC	-Hahnemann Medical College
ICR	-Institute for Cancer Research
IPI	-Illinois Pediatric Institute
JEF	-Jefferson Medical College
JHU	-Johns Hopkins University
MISC	-Miscellaneous
MS	-Mount Sinai Medical Center
MUSC	-Medical University of South Carolina
NCI	-National Cancer Institute
NHLI	-National Heart and Lung Institute
TU	-Tulane University School of Medicine
UMISS	-University of Mississippi Medical Center
UNC	-University of North Carolina School of Medicine
UNCD	-University of North Carolina Dental School and Dental Research Center
VAM	-Veterans Administration Hospital - Miami
VAO	-Veterans Administration Hospital - Oteen
WF	-Bowman Gray School of Medicine, Wake Forest University

1.5 Definition of Terms

In the Application Team Program, a number of terms have evolved that describe the elements and process in this program. Because of their number and unfamiliarity to many readers, these terms are listed and defined in this section for reference.

Problem Originator, or Researcher - An individual actively involved in an effort to reach a specific objective in biology or medicine and faced with a specific technological problem that is impeding progress toward that objective.

Participating Institution - A medically oriented educational institution, hospital, medical center, or government agency having as one of its organization objectives the improvement of medical health care.

Consultant - A member of the biomedical staff at a participating user institution who has committed a portion of his activities to assist the Team in identifying appropriate problem originators at his institution, in understanding and specifying problems in biology and medicine, and in evaluating technological solutions to problems.

Application Team (Team) - A multidisciplinary group of engineers and scientists engaged in problem-solving activities in medicine with the specific objective of affecting the transfer of aerospace technology to solve problems in medicine. The methodology used by the Team involves (1) problem selection, definition, and specification; (2) identification of potential solutions to problems by manual and computer information searching, circulation of problem statements to NASA Field Centers, and contacts with NASA engineers and scientists; (3) evaluation of potential solutions; (4) implementation and adoption by problem originators of aerospace technology as solutions or partial solutions to medical problems; (5) identification of appropriate manufacturers; and (6) documentation.

Problem - A specific and definable tèchnological requirement that cannot be satisfied by commercially available equipment or by application of information available to the problem originator through routinely used information channels.

Computer Information Search - This is a computerized information search of the aerospace information bank established by NASA and made available through six Industrial Applications Centers in the United States. This information bank consists of approximately 750,000 documents that have been indexed and abstracted in the Scientific and Technical Aerospace Reports (STAR) and International Aerospace Abstracts(IAA).

Impact - Information is given to a problem originator with the result that he changes his activities in a way that enhances his progress toward a medical objective. An impact is thus analogous to a technology application except that some requirement for a technology application is not satisfied.

Potential Technology Applications - The search for NASA technology by the application team leads to the identification of relevant technology that offers strong potential for solving the particular problem. A potential technology application occurs when the Team and the problem originator agree on the applicability of specific NASA technology to the particular problem and when a reasonable plan for achieving implementation exists.

Technology Applications - The key factor that permits a potential technology application to become a technology application is implementation. A technology application occurs when aerospace technology is implemented to solve a problem different from the one for which the technology was originally developed.

The NASA impedance pneumograph (ZPN), shown in figure 3 and described in NASA document SP-5054, was recommended for the solution of this problem. The NASA impedance pneumograph was used on Mercury, Gemini, and Apollo missions to measure the respiration rates of astronauts in flight. The device works on the principle of applying a 100-kHz electrical signal across the thorax and measuring the change of impedance as the thorax changes in size. The electronic package is about the size of a cigarette lighter, and thus can be comfortably attached to the patient. It is electrically safe and is battery operated.

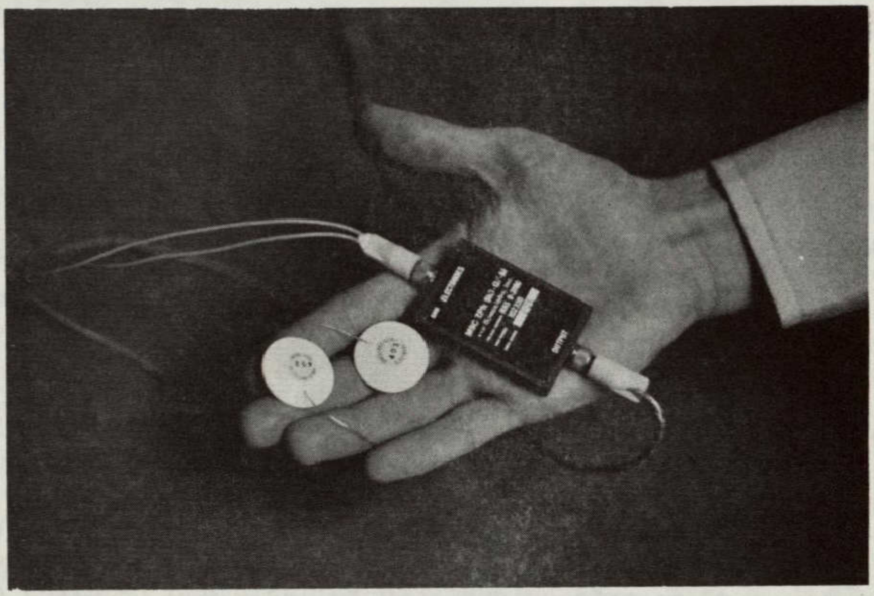

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Figure 3. NASA Impedance Pneumograph.

2.0 TECHNOLOGY APPLICATIONS, POTENTIAL TECHNOLOGY APPLICATIONS, AND IMPACTS

2.1 Technology Applications

During the reporting period, five applications of aerospace technology were accomplished and are discussed in the following summaries:

PROBLEM DU-88 *Respiratory Measurement in Epileptics*

A device developed for measuring respiration of astronauts has proved useful in the clinical study of epileptics.

Epilepsy is an intermittent disorder of the nervous system caused presumably by sudden, excessive, disorderly discharge of cerebral neurons. The discharge causes various degrees of reaction, but, in general, it results in an almost instantaneous disturbance of sensation, loss of consciousness, and, occasionally, convulsive movements.

The magnitude of the problem of epilepsy and its importance to society can hardly be overstated. Statistics show that at least 500,000 persons living in the United States are or have been subject to seizures. Epilepsy may begin at any age, and it may occur only once during the lifetime of an individual or as much as several times a day.

At the present time, an increasing quantity of research is being directed toward the various conditions of epilepsy. Recently, the Veterans Administration established two Epilepsy Centers--at Durham, North Carolina, and Hew Haven, Connecticut. The Epilepsy Center consists of four rooms for continuous monitoring of various physiological parameters for a patient who is undergoing a seizure. In addition, a video tape of the patient is made so that the nature of the seizure can be carefully studied. Monitoring takes place over a period from 8 to 24 hours. During this period, the EEG is monitored as well as the ECG. Respiration rate is also monitored because, during the time of a seizure, apnea can occur for periods of 10 to 20 seconds. At the present time, respiration rate is monitored by a thermocouple mounted in the nose; however, this technique is unreliable and requires critical positioning. For example, if the patient breathes through the mouth instead of through the nose, an error in reading occurs. In addition, the thermocouple mounted in the nose provides some discomfort for the patient, particularly for long-term monitoring. A means was required for measuring respiration rate that avoids the problems encountered in thermocouple monitoring.

PROBLEM NCI-4 *Controlled Rate of Freezing a Liquid*

Leukemia, a disease that kills about 15,000 Americans annually, is characterized by a proliferation of the tissue that forms white blood cells. Although the white cells in the blood can either increase, decrease, or remain constant in number, the bone marrow where the cells are formed will proliferate.

Treatment of leukemia involves killing the cancerous white blood cells in the blood and in the bone marrow using drugs or radiation. This process can cause loss of all bone marrow so that normal white cell production cannot occur.

When this loss of bone marrow occurs, white cells must be resupplied to the patient. For this purpose a bank or storage facility of white cells is required. This is impossible at present because adequate storage procedures are unavailable. Although red cells can be preserved by freezing, white cells are now destroyed by the existing freezing and thawing procedures. One important parameter in freezing white blood cells is believed to be the rate of freezing. Rate of freezing cannot at present be controlled because of the plateau in cooling rate when the latent heat is released at the freezing point.

The present method for freezing is a liquid nitrogen system, which cools a secondary liquid, which in turn cools the cells containted in a flat Teflon bag. To prevent contamination of the cells, it is desirable that any new technique utilize a Teflon container.

The basic requirement is to have a method of first detecting the onset of freezing and then increasing the heat transfer rate during the release of latent heat so that a nearly constant rate of freezing can be maintained from room temperature to -50°C.

The problem was forwarded to the Jet Propulsion Laboratory (JPL), where Mr. L. S. Doubt and Mr. W. Tener suggested the configuration shown in figure 4. The cells are held in a Teflon bladder, which is surrounded by a copper heating element and liquid nitrogen tubes. During the cooling cycle from room temperature to the freezing point, the heating coils control the cooling rate. At the freezing point, heat is turned off and the latent heat of the cells is rapidly removed. Then the heat is turned on again to control the rate until -50°C is reached.

Although the proposed solution originated at JPL, implementation of this idea was pursued by the Goddard Space Flight Center (GSFC) because of the geographic proximity of the National Cancer Institute (NCI) and GSFC. GSFC personnel used a computer-aided design to optimize the basic configuration before hardware construction. The computer analysis utilized the same techniques that NASA uses in space applications such as thermal balance in spacecraft. Coordination between NCI and GSFC research staff members was closely maintained to insure that the final device met all medical and engineering requirements.

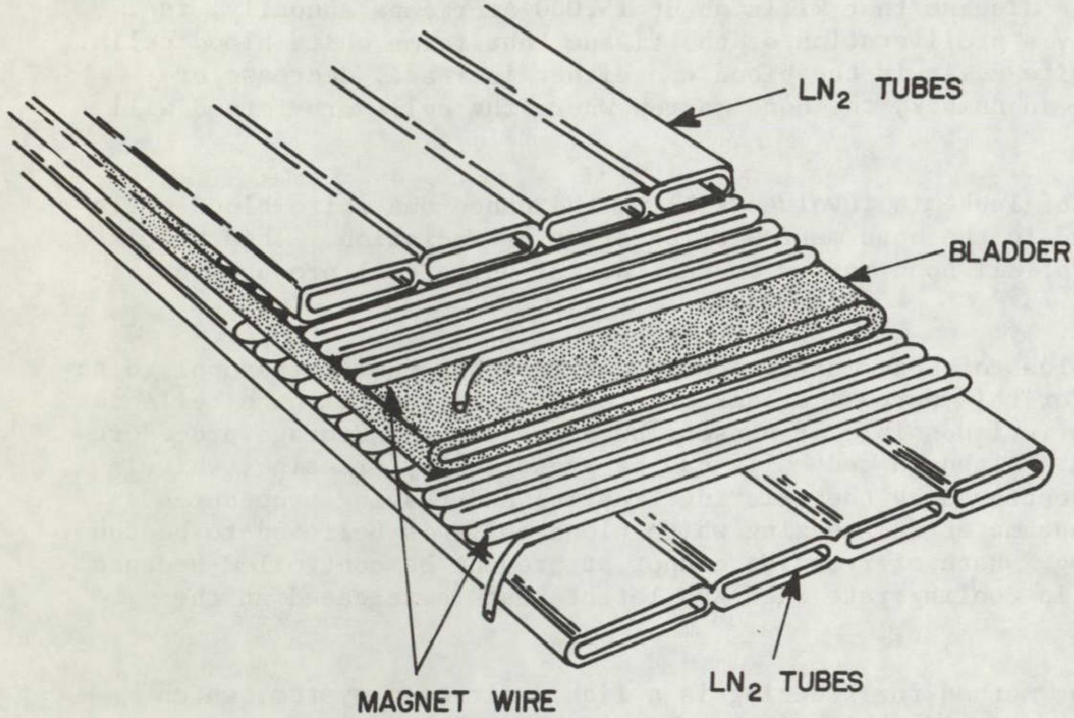

Figure 4. Freezing Cell Sandwich.

Initial studies showed that a minor modification of the initial concept was required. A computer simulation model was developed that allowed design modifications to be quickly evaluated. Following this phase, an experimental model of the design was built and successfully tested. An improved model was delivered to NCI in early 1974.

As is apparent from the preceding discussion, the original requirement was for a system to allow the freezing and storage of white cells to be used in the treatment of leukemia. Evaluation of the NASA-developed freezing unit has proceeded in the past six months using bone marrow cells. The freezing of bone marrow cells is at least as important as freezing white cells and is likewise involved in a potential treatment for leukemia. The hypothesis is that following complete destruction of cancerous white cells and bone marrow in a leukemia patient, it may be possible to regenerate

normal bone marrow tissue in the patient by the introduction of a sample of normal bone marrow cells from an individual whose tissue is compatible with that of the patient. The evaluation at NCI to date has involved experiments with dogs. A quantity of bone marrow is removed from the experimental animals. The animals' white cells and bone marrow tissue are destroyed by radiation. Quantities of bone marrow cells are reintroduced into the experimental animal from which the cells were originally removed and the recovery of the animal is observed. Recovery rates for the animals utilizing fresh bone marrow cells which have not been frozen is approximately 70 percent,and recovery is complete in approximately 20 days. When the bone marrow cells have been frozen using the NASA-developed unit, thawed, and then introduced into the experimental animal, recovery rates are the same as they are with the introduction of fresh bone marrow cells. To date, bone marrow cells involved in this experimental program have been frozen at 1°C per minute; future experiments will involve working at more rapid rates of freezing--up to 10°C per minute. Additionally, the frozen bone marrow cells have been stored for limited periods of time; future experiments will involve storage of several months. Similar experiments using other tissue-freezing instruments at NCI have not been as successful.

Investigators at NCI report that recorded temperature profiles using the NASA freezing unit show a deviation of only approximately 1°C from a linear temperature descent at a rate of 1°C per minute. Additionally, these individuals seemed impressed by the reliability of the NASA unit; they have been able to place bone marrow cells in the freezing unit, and leave it unattended, and consistently obtain good results.

At present, complete technical documentation on the freezing unit is being prepared at NASA's Goddard Space Flight Center. This documentation will be made available and reported as it becomes available. Two photographs of the core unit of the prototype freezing apparatus built at NASA's Goddard Space Flight Center are presented in figure 5. Additionally, as more specific information and data become available at the National Cancer Institute on continued evaluation of the unit, this information will be reported.

PROBLEM TU-22 *X-Ray Microplanigraph*

An aerospace method used for analysis of printed circuit boards is being applied to obtain improved X-ray techniques for cancer detection.

The problem originator wished to develop an instrument capable of detecting tumors deep within the body. In addition, he wished to determine whether or not the tumor is malignant or benign and the extent to which the tumor has spread. One common method for detecting tumors is the X-ray. Unfortunately, small tumors are difficult to detect because the background level of signal of the X-ray is vastly increased by the thickness of the body. It is desirable to develop a technique whereby X-rays can be made of lamina regions only. Using this technique, X-rays can be made of thin

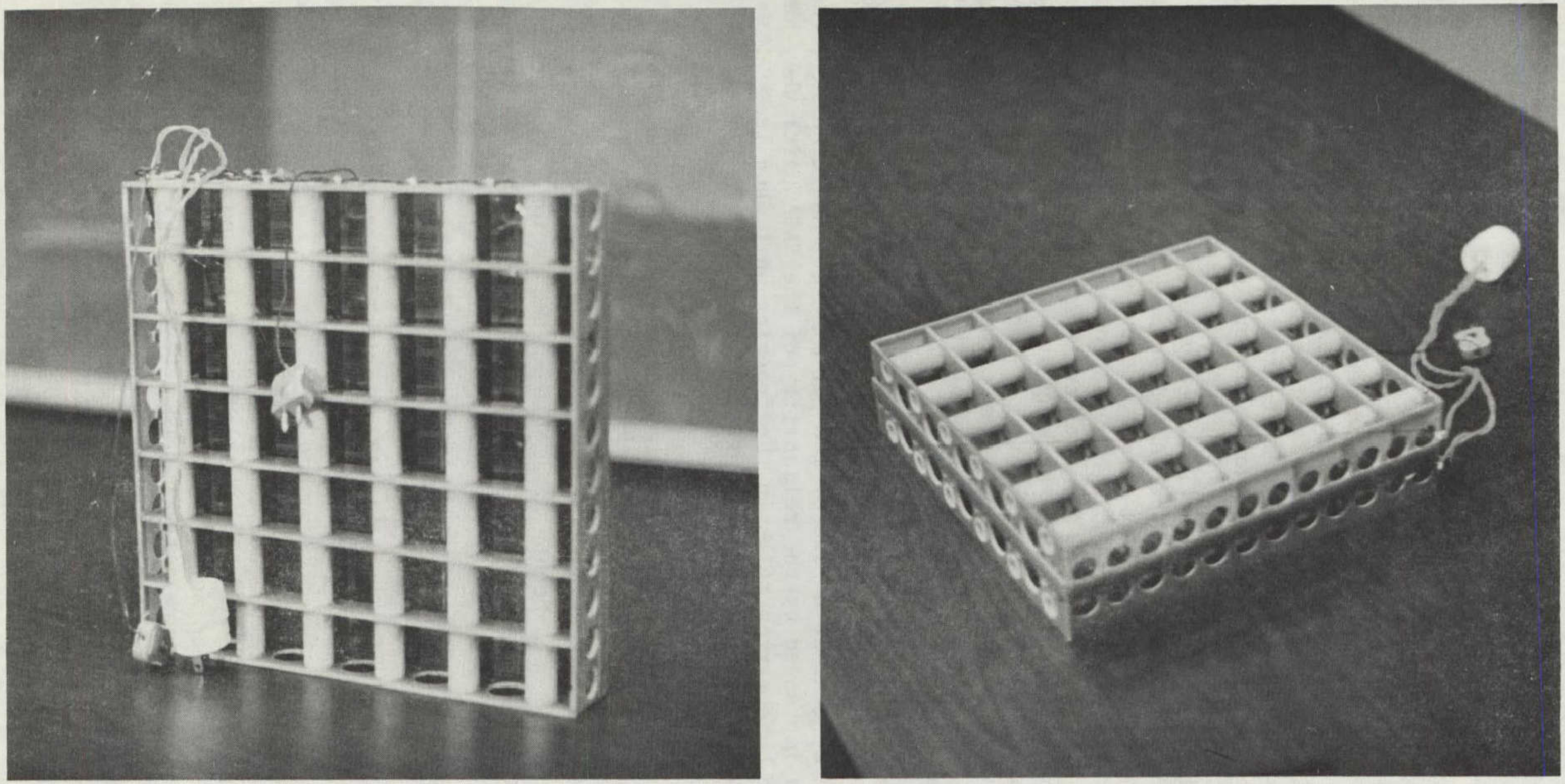

Figure 5. Two Different Views of the Prototype of the NASA-developed Tissue Freezing Unit.

laminae, and smaller tumors could potentially be detected. Conventional medical tomography has been utilized for many years to detect thin laminae of the body. However, the resolution of such systems is inadequate to meet the needs of the radiologist. Even though the background signal-to-noise ratio is improved by conventional tomography, the resolution is inadequate to significantly improve the tumor detection capability of the physician.

The technique of making X-rays of thin laminae with high resolution is called X-ray microplanigraphy, and a development in NASA has significantly increased the possibility for developing such a technique for medicine. NASA developed a technique for inspecting multilayer printed circuit boards layer by layer with a resolution of 0.002 centimeters. This technique was developed by a NASA contractor at the Illinois Institute of Technology and is described in NASA document A70-24577. Basically, it involves moving the X-ray source and the detector in a particular geometrical arrangement so that only thin laminae are measured with very high precision. This work was funded by the Marshall Space Flight Center, and the Team was apprised of the work by computer search No. 2377 by the North Carolina Science and Technology Research Center. Following initial discussions of the technique between the Team and the problem originator, the problem originator visited the NASA contractor for detailed discussions. Subsequently, the problem originator submitted a proposal to the National Cancer Institute for investigation of this particular technique. In May 1974, the National Cancer Institute issued a grant to the Tulane University School of Medicine for study of this new development.

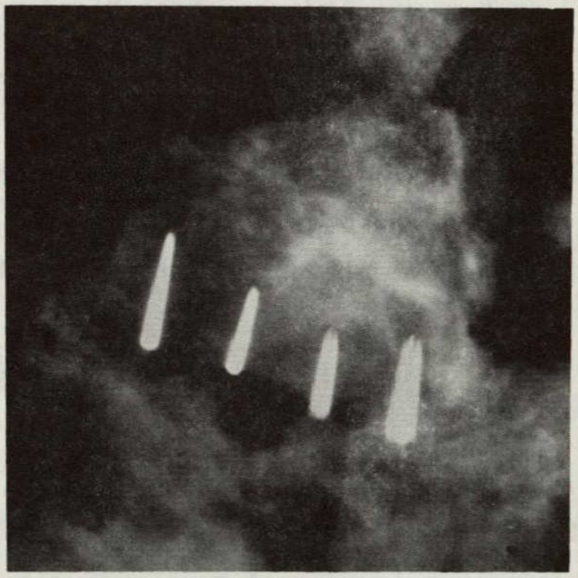

Figure 6. Microplanigraph of Human Mammary Carcinoma.

The above figure is an X-ray microtomogram of a test specimen embedded in fresh breast tissue. The conventional X-ray could not identify a spicular septum of this size (300 microns wide and 70 microns long).

PROBLEM VAM-6 *Negative Pressure Chamber*

Respiratory distress syndrome is a major cause of death in the newborn. It is estimated that more than 20,000 babies succumb to this disease in the United States each year. Respiratory distress syndrome is a condition in which the lung progressively lose their ability to oxygenate the blood. It is thought to be due to the absence of a surfactant material normally present in the alveoli. This material tends to equalize the tension exerted on the alveolar wall. Without the material, the smaller alveoli tend to collapse. The number of collapsed alveoli increases until the lungs are no longer capable of performing the oxygenation mission.

Recently, researchers at several medical centers in the United States and Canada have reported encouraging results with the use of continuous positive airway pressure (CPAP) and continuous negative pressure (CNP) therapeutic techniques. The CPAP method uses an endotracheal tube which continuously forces oxygen-rich air into the lungs, while the CNP method keeps the infant's lungs expanded by subjecting the chest to continuous negative pressure. The negative pressure around the chest helps the infant to expand his lungs and to maintain the proper residual volume of air. If life can be sustained for four days by either method of treatment, the missing alveolar substance will be present in a sufficient quantity for normal unassisted breathing to occur.

The CNP method has been employed by specialists at the University of Miami School of Medicine. They were among the first to utilize the technique. First, a commerically available respirator was modified to produce a constant negative pressure. It has saved the lives of several infants. To improve this initially improvised system, the University of Miami medical team wished to fabricate a CNP chamber that would cover only the infant's thorax, arms, and upper abdomen. Such a system offers advantages over the use of continuous positive pressure in the airways;

(1) It avoids tracheal intubation and leaves the face free for nursing care. This point is of great importance since, in addition to feeding the infant, it is normally necessary to suction mucus from the infant's trachea at frequent intervals. The CPAP must be discontinued during such nursing care.

(2) Its interference with venous return to the right heart will be minimal.

(3) It avoids the increase of air in the gastrointestinal tract.

The University of Miami School of Medicine medical team encountered several problems in the development of the new CNP chamber. The waist seal leaked excessively, and both the neck and waist seals caused abrasion to the infant's skin. It was at this point that the University of Miami medical team approached the RTI Biomedical Application Team for assistance.

The technology employed in the body seals of the Lower Body Negative Pressure System on the NASA 1973 Skylab Mission was applied directly in the design and development of a new CNP chamber. NASA Marshall Space Flight Center (MSFC) and NASA Johnson Space Center (JSC) engineering personnel assisted the Department of Biomedical Engineering at the University of Miami in the design of the air seals required at the waist and neck in the CNP unit. The resultant seals are direct adaptations of the NASA Lower Body Negative Pressure waist seal.

A CNP chamber was fabricated and subjected to clinical evaluation. Several infants suffering from hyaline membrane disease were treated using the CNP chamber. Medical personnel are very pleased with the unit, especially the neck and waist seals which have proved to be effective, easy to use, and adaptable to considerable variation in infant size.

This effective application of NASA technology has produced an item with commercial potential. Efforts are now underway to locate an acceptable manufacturer.

PROBLEM VAM-26 *Cancer Center Organization and Management*

More than 20 major cancer treatment centers are currently being established throughout the United States. They will utilize state-of-the-art treatment techniques with a major emphasis placed on speed of treatment. Hopefully, in the cancer center the combined skills of the hospitals (surgical, radiological, etc.) will be jointly focused on the patient, as it is done in a health-screening clinic. This approach appears vital to successful cancer treatment. Unfortunately, it is in conflict with the established procedure found in some hospitals.

Major hospitals are usually organized into departments by skills (e.g., surgery, medicine, etc.) with minimal interaction between departments. The cancer center with its disease-oriented organization (lung cancer, leukemia, etc.) must overlay this structure, and be able to jointly mobilize the talents of each department in the attack on cancer. The problem originator asked if NASA had any management techniques that might assist with this organizational and management problem.

The Team contacted Mr. Raymond A. Kline, Assistant Associated Administrator, Office of Organization and Management, at NASA Headquarters and explained the problem. Mr. Kline suggested that the problem was very similar to the task of combining the diverse skills of a large NASA center to accomplish a complex NASA program. He felt that Marshall Space Flight Center (MSFC) was especially experienced in this area because of their booster development programs.

Mr. Kline's suggestion was discussed with Mr. Juan Pizarro of the Technology Utilization Office at MSFC. Mr. Pizarro suggested contacting Colonel Lee B. James. Colonel James, who is currently with Boeing Aircraft Company, had held numerous NASA management positions. These included Deputy Director of the Apollo Program, Director of Program Management at MSFC, Director of the Saturn Program, Program Manager of the Saturn 5 Program, and Program Manager of the Saturn 1 and 1B Programs. While a Professor of Cybernetics at the University of Tennessee, he also wrote a book entitled Management of NASA's Major Projects.

The team contacted Colonel James, who quickly received corporate approval to assist the problem originator. This approval included sufficient funds for a 3-day visit to the Comprehensive Cancer Center of Greater Miami (CCC) to consult with the problem originator. This was explained to the problem originator, who contacted Colonel James and initiated plans for him to visit Miami on January 27-29, 1975. The problem originator also agreed to assume part of the cost.

Colonel James was supplied much literature describing what is planned at the CCC. On his own, he contacted a close friend who is administrator at another cancer center and discussed the funding aspects of such a center. He also spent much time reviewing pertinent NASA management techniques.

On January 27-29, 1975, Colonel James visited the CCC in Miami, Florida. Dr. C. Gordon Aubrod, Center Director (problem originator) carefully arranged Colonel James' itinerary (see enclosure 1). Time was allocated for Colonel James to be briefed by Dr. Zubrod, his staff, and key hospital and university personnel from outside the CCC. On Monday and Tuesday, briefings began at 9:00 a.m. and continued through 6:00 p.m. with lunch being brought in. On Wednesday, briefings terminated at 2:00 p.m. Several officials not listed on the itinerary briefed Colonel James as the schedule permitted. Time was also allocated to allow Colonel James to consult privately with Dr. Zubrod several times a day.

Colonel James quickly noted that the organizational structure being used was a matrix style designed to give a multidiscipline approach--truly an unusual management technique, but one used extensively by NASA on their large development programs. Thus, Colonel James' impressive NASA management experience was directly applicable. Drawing on this NASA management experience and on the insights gained from the intense briefings, he compiled a report, which he presented to Dr. Zubrod (see enclosure 2). The report is divided into two parts. The first includes his observations, comments, and suggestions concerning the planning that was currently in progress. The second part suggests potential downstream problem areas.

From Colonel James' visit, Dr. Zubrod received a unique management review of his efforts. Both his list of priorities and goals--so important

in this matrix style management approach--were carefully checked, and several alternates were suggested. Potential problem areas were noted, but most of all, his overall management approach was verified by a recognized successful manager who possessed extensive experience in the use of this unusual management technique. Dr. Zubrod and several of his staff have personally expressed their gratitude (see enclosure 3). As further evidence of the significance of Colonel James' contribution, the Team has been asked to investigate the possibility of Colonel James returning in 1976 to repeat this same type of intensive management review. This possibility is being explored.

Enclosure 1

UNIVERSITY OF MIAMI
MIAMI, FLORIDA 33152

Mailing Address
COMPREHENSIVE CANCER CENTER OF GREATER MIAMI
SCHOOL OF MEDICINE
P. O. BOX 875, BISCAYNE ANNEX

Location
JACKSON MEMORIAL HOSPITAL

ITINERARY FOR COLONEL LEE JAMES
MONDAY, JAN. 27-WEDNESDAY, JAN. 29

ORIGINAL PAGE IS OF POOR QUALITY

MONDAY, JANUARY 27

TIME	APPOINTMENT	LOCATION	PHONE
9:00 AM	C. GORDON ZUBROD, M.D., DIRECTOR COMPREHENSIVE CANCER CENTER	CENTRE HOUSE	547-6096
	MR. MICHAEL SIEGEL, ADMINISTRATIVE OFFICE, COMPREHENSIVE CANCER CENTER	CENTRE HOUSE	547-6096
	JOHN E. HEALEY, M.D., PROFESSOR AND DIRECTOR OF CANCER CONTROL	CENTRE HOUSE	547-6096
11:00	JACOB COLSKY, M.D., ASSOCIATE PROFESSOR, DEPARTMENT OF MEDICINE	CENTRE HOUSE	547-6096
12-1:45	LUNCH		
2:00	SHELDON GREER, PH.D., PROFESSOR DEPARTMENT OF MICROBIOLOGY	3036 MEDICAL SCIENCE BLDG	547-6750
3:30 (HALF-HOUR)	BERNARD J. FOGEL, M.D., ASSISTANT VICE PRESIDENT FOR MEDICAL AFFAIRS	1140A MEDICAL SCIENCE BLDG	547-6566
5:00	ROBERT ZEPPA, M.D. PROFESSOR AND CHAIRMAN, DEPARTMENT OF SURGERY	C2011A MEDICAL SCIENCE BLDG	547-6721

TUESDAY, JANUARY 28

TIME	APPOINTMENT	LOCATION	PHONE
10:00 AM	MARK A. FREEDMAN, M.D., ASSOCIATE DEAN HOSPITAL AFFAIRS	1142A MEDICAL SCIENCE BLDG	547-6004
1:00 PM	MICHAEL TRONER, M.D., ASSISTANT PROFESSOR, DEPARTMENT OF MEDICINE	VA HOSPITAL	324-4455
2:00	HERVY E. AVERETTE, M.D., PROFESSOR DEPARTMENT OF OBSTETRICS AND GYNECOLOGY	6 CENTRAL JACKSON MEMORIAL HOSPITAL	325-6951

REPORT ON ORGANIZATION OF THE MIAMI COMPREHENSIVE CANCER CENTER

The undersigned was requested by NASA, through the Research Triangle in North Carolina to consult on the Comprehensive Cancer Center (CCC) organization. The proposed organization is a matrix style organization designed to give a multidiscipline approach of a disease oriented Cancer Center into a discipline oriented Medical University and Hospital structure. The major problem in contributing as a consultant is that the CCC organization is in the proposal stage and has not been in anyway tested at this time. Therefore, these comments will be given in two parts. The first part will be observations, comments, and suggestions concerning the planning steps now taking place. The second part will suggest potential downstream problem areas resulting from this environment on this type of organization. In both cases, the conclusions were reached by very short discussions with some of the personnel involved, primarily as shown on the attached agenda.

1. The various reactions to the planning thus far, might be summarized as follows:

a. Although hospitals are traditionally discipline oriented, the need for a multidiscipline approach, particularly in an area such as cancer, is rapidly and almost universally accepted locally.

b. There is no reason a matrix type, multidiscipline organization for the CCC will not work. It depends on the implementation.

c. You have the total backing of the University organiztion, and of practically all of the individuals involved, in your charter and your approach. You have somewhat more "wait and see" attitude from those outside the Medical Center, particularly in private practice.

d. You have a number of areas to watch: the total medical oncology department, transfer of the radiology department, requirements in pathology, coordination of surgical needs, the good will requirements ouside the University area, the coordination of Florida's overall cancer activities, the Papanicolaou Center, the various affects of personnel changes, the relationship with pediatric-oncology, the effects of tampering with the incomes of those involved, etc. Although all of these are soluble and there is no reason to think they are not being solved properly, some of these items will be given additional comments.

e. You have one problem area which surmounts all others. It must be solved-resources, to include buildings, beds, adminstrative space and labs. If a suitable solution, such as the Cedars, is provided to you, in time, almost all other problems will go away. This assumes the facility is properly financed. You are then assured of continued Medical Center support, most people problems will disappear, the CCC will have a success image, personnel can retain their private practice, the CCC can better centralize and coordinate its activities, and so on. No other solution is a good second. Only Jackson, with many bad features has sufficient facilities and beds, but it would be a second class solution.

f. You do have the credentials to insure a favorable solution to the above. These include: you are well known, understand the Washington D.C., environment, understand the financial support channels, have proven ability, you were requested by those internal to this Center, you have moved carefully and have proper personality.

g. There are some problems. Neither you nor Mike have a recent nor an abundant background in hospital or in Medical Universities. You have no one who completely fills that gap. Some of the fine points of smoothing the waters are being missed although no major damage has apparently resulted. Personnel changes affect many people who may not be easily recognized. General agreements to job changes must eventually be understood in detail. If Dr. Lessner is the answer to working inside, then his status must be finalized. Since he represents local medical oncology, his overall situation is not understood and this causes unnecessary questions of the CCC.

h. Most agree that radiological works (except diagnostic) and all medical oncology should be transferred to the CCC. To leave them or divide them leaves subtle inference not found in other disciplines. Pediatrics, as a facility, should stay as it is. Pediatric oncology must be considered in the CCC. Surgical support appears to be no problem.

i. Key personnel will be attracted to you, to the cancer solution, by salaries, by recognition, by consideration of their private practice, by this location and by a well supported major facility. Only the last item is a major problem. They must then be picked carefully to cooperate, blend and to have sufficient ability. Their private practice may compete with existing outside practices and must be watched. Locally, the individual voice in staying with the University or moving to the CCC must be a major factor in where each one goes, i.e., the individual and the deparment must be considered.

j. The affects of the CCC down in each organization, above or below the man addressed, must be considered. Does it affect department income? Does it affect other salaries?

k. Each department head should be visited frequently for general discussion and good will. For instance, if Dr. Averette is physically moved then Dr. Little's Ob & Gyn Department's major source of income has been removed. It may not be a problem but should be discussed.

l. The County hospitals are grossly under-supported financially and burdened with extraneous care. If Cedars becomes County property or if Jackson is used, as much independence as possible from these controls would be desirable.

m. It appears the teams are being tried in phases, possibly the lung cancer team first. This is good, different solutions for different teams. I haven't been exposed to those in radiology, pathology diagnostic, immunology, therapy, etc., but is is assumed they will be considered in team make-up.

n. The problem will occur when you start balancing the requirements of research and patient care with the prerogatives of individual disciplines. The control features are the dollars involved and the centralized facility.

2. Any suggestions downstream can only be possibilities. The checklist is always worthwhile even though actual experience may dictate an entirely different set of problems. In any case here are some thoughts.

a. The matrix organization is entirely suitable for the CCC. It lacks only direct experience ahead of time. The only way I can see to obtain this is through other similar application. There are three major Comprehensive Cancer Centers and as I understand it, twelve more are now in some form of readiness. Some of these are associated with hospitals and universities and it is believed some are trying the matrix or multidiscipline approach. Since the correlation is direct it is recommended you or some of your staff visit one or more such facility.

b. A fairly slow and careful approach, as you are approaching it, seems to be in order. However, one area is overriding and has everyone watching it as the big indication of success. This is the facility-resources problem. It is recommended you work that problem vigorously and early until the good solution can be indicated to everyone. Those areas needing 60 beds now are not thrilled with a 60 bed total solution.

c. Because Dr. Lessner was the first one involved here with the CCC and because of the obvious correlation of his work to the goals of the CCC, the final determination of his relation

to the CCC is on everyone's mind. Most agree he belongs with the Center. He thinks so too. It is recommended that you and the Dean work this problem directly at an early date. An early solution would be useful.

d. A matrix or multidiscipline organization can cause individuals to lose their identity. Care should be taken to keep them identified with their disciplines and even to occasional rotations.

e. A great deal of care must be given to salaries of individuals. The most difficult area will be those in the discipline portion of the organization. They are not quite owned by their old organization or by the CCC. This should be watched and endorsement given to these individuals for grants since that allocation is not locally determined.

f. Individual recognition is always a major factor. An opportunity exists for being highlighted in the national picture. For early recruitment and progress it is recommended excessive steps be taken to feature individual recognition.

g. It is recommended your effort here, be paralled by an effort to decentralize the goals for the CCC throughout the state. However, because of the potential problems and road blocks it is recommended this be preceded by a statewide campaign of good will.

h. Mike is your direct interface into hospital and university affairs, and a good one. However because no one can have the insight of an insider it is recommended a way be found to supplement this with senior inside counseling and direction.

i. It is recommended you produce more in depth publications. Your Comprehensive Cancer Center Preliminary Program Estimates dated the 20th of December 1974 is excellent but should be carried into much more depth. You may need an internal and external version. Role definition should be carried out in much more detail. In fact you may need University Center assistance in order to set down all that is needed. Those who have agreed in principle are anxious to see the details.

k. As you know the balance among education, research and service is a delicate one as is the balance between rate of growth and good will. Since these are now watched carefully internally it is recommended you find a way of monitoring them with advice from inside the University Center.

1. It is recommended you budget your time so that you can devote considerable effort to the major income sources. These probably require your personal effort, there is a local air of expectancy here, and an early monetary bonanza would solve a lot of early problems. Since everyone realizes they are better off getting started as a collected, concentrated specialty, this momentum must not be lost.

3. In conclusion the CCC is off to a great start. It has been initiated properly. The concept is completely backed. No major road blocks can be foreseen except facilities. With the lead time and decision time involved the facility problem could be disastrous. With the enthusiasm you have generated surely it can be worked as you are working everything else. I would expect to hear great things of this Comprehensive Cancer Center.

Best of luck to you.

Lee B. James

2.2 Potential Technology Applications

During the reporting period, nine problems achieved the status of potential technology applications. This status indicates that an adequate solution to the problem has been identified and implementation is in various stages of accomplishment. These nine problems are discussed in the following summaries:

PROBLEM DU-94 *A Means of Accurately Positioning Tumors With an X-Ray Therapy Device in a Minimal Period of Time*

The researcher, a radiologist, has agreed that a NASA device, termed a solid-state image amplifier (SSIA), shows promise for being the solution to his problem of accurately positioning patients in the beam of an X-ray therapy apparatus. Two of the panels have arrived at Duke University on loan from Marshall Space Flight Center (MSFC). Mr. John M. Knalder arranged for the loan of the panels from MSFC and Mr. Henry L. Martin of MSFC TU office expedited the loan procedure.

The researcher has begun tests to determine whetner the sensitivity and resolution of the panels are adequate so that the panels can serve as an erasible substitute for an X-ray film plate. If so, the panel could serve as an instant X-ray film plate and eliminate the need for X-ray film developing after each preliminary patient positioning.

The promise of an eventual transfer is high enough on this item to warrant investigation into the NASA patent status as a preliminary step toward commercialization. It appears that NASA has waived the patent and it was picked up by the NASA engineer who worked with Westinghouse in the development of the panel.

PROBLEM JHU-4 *Relating BCG and Carotid Pressure Pulses*

Ballistocardiography (BCG) is a noninvasive method of measuring the sum of forces associated with differential blood mass movements between the arterial and venous systems. The problem originator is attempting to utilize the BCG as a mass-screening tool for detecting the onset and types of peripheral vascular changes associated with hypertension. The problem is how to increase the accuracy of the relating of carotid pressure data with the (simultaneously recorded) BCG record, both of which are present in digitized form in computerized patient records.

The potential technology transfer for the solution to this problem has been found in a NASA literature search as NASA Tech Brief 70-10627 ("Simple Data-Smoothing and Noise Suppression Technique"). Although the brief describes

a technique for data smoothing, the technique can also be used to detect straight-line segments in a data string which is very similar to the identification of the beginning of an epoch in the BCG recording.

PROBLEM LSD-1 *New Methods for Cleaning Teeth*

Oral hygiene is conducted using several methods: brushing, flossing, and irrigation. Irrigation consists of directing a stream of water onto the tooth and to the area between tooth and gum. A more effective method is needed to remove plaque from between teeth and between tooth and gum.

Ultrasonic scaling devices are presently being used by dentists for plaque removal. The most common device used is a pointed metal rod which is vibrated with ultrasonic energy. Great care must be taken while using this tool, however, to avoid damaging the teeth or gums. Also, this method does not provide a means to flush the loosened plaque.

A new method for cleaning teeth, which has been suggested by NASA personnel, utilizes an ultrasound energy-coupled water jet. The proposed method not only provides a means of coupling ultrasonic energy to the tooth, but provides continuous flushing of loose plaque as well. This innovative suggestion was made when the team contacted Mr. Juan Pizarro of Marshall Space Flight Center. Mr. Pizarro suggested the team contact Mr. W. N. Clotfelter, who has used ultrasound coupled water streams for fusion weld quality control. This technique was originally reported by Mr. Clotfelter in 1960.

The problem originator is very enthusiastic about the prospective success of this proposed technique. Presently, an applications engineering project is planned, to be handled by NASA personnel at Langley Research Center. The problem originator will assist with clinical evaluation at the Louisiana State University School of Dentistry.

PROBLEM MISC-41 *Fire Protection in Paraplegic Homes*

A HUD-funded project has been established at St. Andrews College for the design and fabrication of suitable housing for handicapped persons because of the strong commitment that this college has historically demonstrated for handicapped students. Four mobile homes will be fabricated, and, at the end of two years, a fifth unit will be built utilizing the knowledge obtained in design/construction/use of the other four units.

In an effort to eliminate fire as a hazard for this type of mobile home,precautions must be taken to utilize fire-resistant paint and wood.

Ames Research Center has been identified as being particularly active in the application of space technology to develop fire-retardant materials.

S. R. Riccitiello of Ames has agreed to the incorporation of a new fire-resistant plywood, which he is developing, into the mobile homes' construction at St. Andrews College. A fire test has been tentatively planned for the fall of 1975.

PROBLEM TU-41 *Computerized X-Ray Microtomography*

Since 1960, the problem originator has explored the concept of diagnostic X-ray microtomography using various specially constructed tomographs. This investigation was significantly aided by the use of the NASA planigraphic techniques developed for nondestructive testing of printed circuit boards. Using this NASA technology, the problem originator has been able to demonstrate a significant improvement in the resolution of conventional tomography. Specifically, he has obtained tomographic images of lamina approximately 0.5 millimeters in thickness. Using this technique, he has demonstrated that the mammary trabeculae could be identified thus significantly improving the ability to detect the presence of a malignant tumor without biopsy. The resolution of the technique will be further improved by the addition of a new 50-micron focal spot X-ray generator.

Unfortunately, the above technique requires numerous exposures in order to obtain the appropriate microtomographs. The problem originator has determined that it would theoretically be possible to make a dramatic change in the approach to tomography that may significantly improve the capability of tomographic systems.

The problem originator requested that the Team investigate a technique for providing the image processing necessary to accomplish this new approach. The Team contacted Dr. William Spuck of the Jet Propulsion Laboratory (JPL), who determined that such a procedure could be accomplished using the image-processing facility at JPL.

At the present time, arrangements are being made to complete the initial processing of the tomographs at the JPL. In addition, the problem originator has submitted a proposal to the National Cancer Institute to investigate this exciting new concept in great detail.

PROBLEM UNC-82 *Method for Measuring Villi Motion*

The problem originator is studying the effect of Villikinin on the intestinal villi. In her experimental preparation a small section of a dog's gut is exposed and observed under a 40-power microscope through a 2-mm by 2-mm grid. Thus six to eight villi are within a grid. Average contraction rates with and without Villikinin are computed by actually

counting the contractions during repeated 30-second periods. Because the observer must count in real time, critics believe that this technique is too subjective. Attempts to record the Villikinin effect by using photomicroscopy have been unsuccessful because of gut movement caused by the animal's respiration and blood-pressure pulsations. However, it is believed that some photographic technique holds promise.

Dr. Montaz N. Mansour, Jet Propulsion Laboratory (JPL), Pasadena, California, suggested that a NASA-developed, servo-controlled, intravital microscope system was directly applicable to this problem. The microscope system, which is currently installed and in use in Dr. Harold J. Wayland's laboratory at the California Institute of Technology, automatically keeps a moving tissue specimen in focus. The system adjusts for motion parallel to the microscope's optical axis. Fortunately, the motion of the dog's gut is also limited to this one axis.

This microscope focus control system is based on the principle that the high frequency content of a T.V. camera output increases as the camera is brought into focus. Thus, as shown in figure 7, in addition to a viewing device, two T.V. cameras are used. Both cameras are slightly out of focus; the target of one camera is slightly in front of the image plane, while the target of the other camera is slightly behind the image plane. The camera outputs are processed to produce a control signal that drives the servo system. This servo system positions the objective lens to keep the microscope's image plane between the two T.V. cameras' target planes. In this manner, the image is kept in focus on the viewing device.

Dr. Mansour verified that arrangements not only could be made for the problem originator to use the microscope system, but also that Dr. Wayland would make his fully equipped laboratory facility available for the necessary animal experiments. Arrangements are now being made for a series of experiments that will be run in August 1975.

PROBLEM VAM-24 *Processing of Rapid Microfluorimetry Data*

The problem originator, as part of a cancer research program to study cellular metabolism has assembled a sophisticated rapid microfluorimetric system. (The basic component is the SSR Instruments Company's Optical Multichannel Analyzer, Model 1205-D.) With this system, he can monitor simultaneously every 30 milliseconds the metabolic processes at 500 sites within the cell. This amounts to a data rate of over 15,000 characters per second. Unfortunately, his data-recording and -processing systems are currently incapable of accommodating rates of this magnitude.

The problem originator contacted NASA Headquarters and requested a loan of a Kennedy recorder (a high speed digital tape recorder) from Dr. H. H. Kim of Wallops Flight Center. Team conversations with Dr. Kim

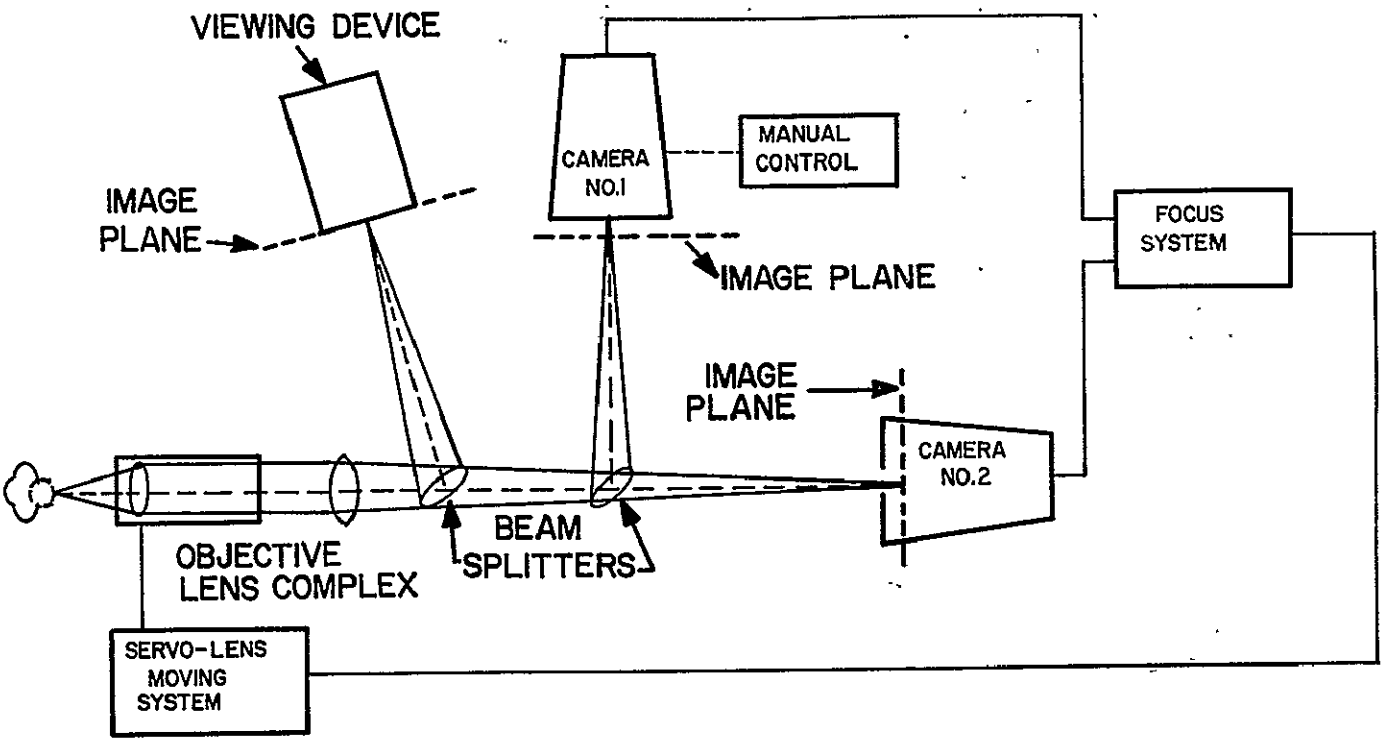

Figure 7. Intravital Microscope System.

revealed that the recorder was in use. The conversations also revealed that Dr. Kim currently uses an SSR Instruments Company's Optical Multichannel Analyzer, Model 1205-D, and that he was directly involved in the development of that unit.

Dr. Kim and the problem originator discussed the problem during an inspection of the laboratory facility and of the existing instrumentation. Dr. Kim learned that his instrumentation system and his data-processing methods were basically identical to those proposed by the problem originator. Therefore, it became apparent that both the experience gained during the development of the NASA unit and the existing software were directly applicable to the problem.

Dr. Kim and Dr. Peter Cervenka, both of Wallops Flight Center (WFC), consulted with the problem originator and assisted him with the design, assembly, and testing of the instrumentation system. Dr. Cervenka also assisted with the first series of experiments. He processed the resulting data at WFC, and he worked closely with the problem originator to determine the most appropriate data presentation formats. Data from subsequent experiments were also processed at WFC.

This assistance has effected a considerable savings in the time and cost of this cancer research. It has also made it possible for the problem originator to more fully appreciate the potential of the instrumentation.

PROBLEM VAM-28 *Sleep Study Monitoring System*

The problem originator is developing an instrumentation system to permit conducting sleep-monitoring studies in the patient's home. While he has already developed several parts of the system, he does not have an acceptable method for mounting the necessary electrodes.

Dr. William H. Shumate, JSFC, was called at Mr. Robert Zimmerman's, (NASA Headquarters) suggestion. Dr. Shumate reported that his group had worked with Dr. James D. Frost, Jr., of the Methodist Hospital in Houston, to develop an instrumentation system to solve a problem identical to that described by the problem originator. He also believed a set of equipment could be made available to the problem originator.

Dr. Shumate's instrumentation system is designed to collect EEG, EOG, EMG, and head motion data. The electrodes are attached to a soft helmet (see figure 8) in their proper relative locations. The overall system is portable, and it provides a rapid and simple means by which neurophysiological data can be obtained by the patient in his own home with the taped data being returned to the laboratory for analysis. The system had been designed primarily for the study of sleep.

This was explained to the problem originator, and he immediately contacted Dr. Shumate. Arrangements have been made for the first available system to be loaned to the problem originator for evaluation.

PROBLEM VAM-32 *Cardiology Information Presentation Techniques*

Dr. Gordon, of the University of Miami, has been involved in the development of a cardiology teaching manikin for over 5 years. His initial models simulated a single disease state. Three years ago, he began the

Figure 8. Skylab Astronaut Wearing Sleep Cap in Flight.

development of a multiple-disease-state manikin. He is presently finishing a final prototype that is capable of simulating approximately 50 disease states. As the number of simulatable disease states has increased, the quantity of supplemental data that must be presented has become enormous. It includes patient histories, electrocardiograms, X-rays, hemodynamic data, and responses to medical and surgical treatments. These data must be organized and arranged for presentation and must be integrated with the manikin programming.

Dr. Gordon is very concerned with the quality of the presentation of supplemental data. The techniques used must insure the maximum efficiency in visual data transfer. He asked if the National Aeronautics and Space Administration, in their handling of enormous quantities of data, had not

encountered and solved similar types of data presentation problems. If so, could not some of the resulting techniques be applied in solving this manikin data presentation problem.

During a routine review of NASA technical literature, the RTI Team member discovered a report by Mr. Sylvester A. DeMars of the Kennedy Space Center (KSC) entitled Human Factors Considerations for the Use of Color in Display Systems (N75-14446). This report was brought to the attention of the problem originator. He was intrigued and very interested in exploring the applicability of these techniques to the manikin data presentation problem.

Working closely, the team member and Mr. Fred Schoenberger of the KSC Technology Utilization Office arranged for Mr. DeMars to visit with the University of Miami personnel associated with the manikin project. On June 6, 1975, Mr. DeMars met with the chief engineer of the manikin project, Mr. Darrell Patterson, and the Director of Instructional Resources for the University of Miami, Mr. John Fisk. The manikin project was discussed, and samples of 35-mm slides to be used in the manikin data presentation system were studied. Mr. DeMars noted how some of the slides were properly prepared,while others were less than optimal. He presented findings from his work at KSC to support these conclusions. The University of Miami personnel were enthusiastic and immediately started arranging for Mr. DeMars to examine other slides.

Mr. Schoenberger submitted an RTOP proposal to NASA Headquarters. It was approved and work was initiated. Working relationships were established between KSC personnel and both the manikin project personnel and the University of Miami medical communications personnel. While KSC recommendations regarding color and information content of photographic slides have already been incorporated into the manikin slide presentation program, the university medical communications personnel have expressed considerable interest in applying the concepts to other slide programs. Thus, this project not only will accomplish the transfer and application of NASA technology to the manikin project but also will have the potential of introducing this NASA technology to all of medical education.

2.3 Impacts

The Application Team's efforts often provide a significant benefit to the researcher even though no technology application has been accomplished. During this reporting period, Team activities had significant impacts on the researcher's activities in three such problems that are discussed in the following summaries.

PROBLEM DU-89 *ECG Telemetry Measurements of Physically Active Subjects*

A research team at the Duke University Medical Center is investigating the effects of workload on subjects in a hyperbaric environment. It is important to quantify these effects to assess the dangers and physiologic alterations of deep-sea diving as well as hyperbaric operating and therapeutic procedures. ECG and the R-wave rate are good indices of workload as the heart responds to an increased demand. Unfortunately, the ECG signal is severely degraded by the muscle noise attendant with work activity. A large part of this artifact is generated by the ECG electrodes moving relative to the body during body movement and to changes in electrolyte concentration and composition in the presence of sweat. An improved electrode for this application would substantially reduce the muscle noise problem.

The problem originator was informed of the existence of the NASA spray-on electrodes (Tech Brief 66-10649, "Spray-On Electrodes Enable ECG Monitoring of Physically Active Subjects"; Technical Note TND-3414, "Dry Electrodes for Physiological Monitoring"; and Aerospace Med 37, #8, "Dry Electrodes for Physiological Monitoring".) These electrodes are effective in combating the muscle noise problem. They are also inexpensive and easy to apply. The problem originator is now using the Hauser ECG Spray-On Electrode Kit (2965 Peak Avenue, Boulder, Colorado 80302) for ECG workload experiments.

PROBLEM TU-10 *Quantization of Heart Tissue Hardness*

Techniques developed to study aerospace materials have been used to study the human heart during pathological examinations.

Examination of the various organs of the human body following death can reveal not only the cause of death but also other conditions affecting the person at the time of death. Research at the Tulane University School of Medicine has shown that, in some cases, a peculiar softening of the heart tissue can be seen in patients that did not die of heart disease. The cause of this unusual softening is not known, but a number of factors are believed to be important. For example, there appear to be an infarction and a definite softness in the heart tissue. The reasons for this are being studied in experimental work using rats in which the blood is cut off temporarily from portions of the heart in order to discover the changes in the heart tissue. Simultaneously, studies are being conducted on human hearts in autopsy examinations to determine whether this soft region can be attributed to any known condition of the human prior to death. In order to

carefully characterize these soft regions, a means of measuring softness of the heart tissue is required. The researcher has attempted to use a conventional eye tonometer for this purpose, but the results have not been reproducible.

PROBLEM UNC-85 *High Speed Remote Stirrer*

In evaluating the virus-killing capability of certain drugs, a set amount of the drug is injected into a known virus population, and the two are rapidly and completely mixed. After a specific time delay, a 1-cm^3 sample is withdrawn. The sample is immediately mixed with another chemical to prevent any further chemical activity. The sample is then processed to determine what percentage of the virus population has been killed.

The problem originator has developed a laboratory setup for conducting these evaluations. He suspends the virus population in a liquid medium. The liquid is then forced through a tube at turbulent flow rates. The drug is injected at a constant rate into the turbulent stream. A specific distance downstream from the injection site a 1-cm^3 sample is withdrawn using a spring-loaded syringe. The chemical that arrests the activity in the sample is preloaded into the 1-cm^3 syringe. Mixing of the sample and the chemical is provided by the turbulence inside the syringe. With the exception of this mixing, the entire system works well. Some additional mixing method is needed which will give complete and nearly instantaneous mixing (less than 0.1 of a second) of the sample and the arresting chemical. The mixing is to be performed inside a 1-cm^3 syringe.

A magnetic stirrer would seem appropriate. However, available mixers require the sample container to set on the stirrer. This is not possible in this application. Some type of stirrer is needed that will fit around the barrel of a 1-cm^3 syringe. The outside diameter of the barrel is approximately 0.3 inch.

Team personnel discussed the problem and concluded that a small AC motor field-winding could be designed that would create an apparent rotating magnetic field. With the coil placed around the 1-cm^3 syringe barrel and a small magnet stirring bar placed in the syringe, the rotating field should spin the magnet stirring bar at 1800 or 3600 rpm. The idea was further discussed with other RTI staff members and all agreed that a competent AC motor designer should be able to develop such a stirrer.

The team member described the idea to the problem originator and suggested that he contact Mr. Richard Boynton of Sperry Rand in Durham, North Carolina. The Team had worked with Mr. Boynton on a previous problem and had found him very knowledgeable about AC motors.

Following the Team recommendations, the problem originator met with Mr. Boynton and his colleagues. Once the problem and its constraints were

understood, Mr. Boynton and his colleagues designed and constructed several small AC motor field-coils. The coils operated from 110 volts, 60 Hz power, and spun the magnetic stirring bar at 1800 rpm. Apparently, the stirring bar was sufficiently unstable that no special starting equipment was required. The new coils were tried in the problem originator's laboratory. They completely solved the stirring problem.

3.0 SUMMARY OF TEAM ACTIVITY DURING REPORTING PERIOD

The following is a summary of project activity undertaken by the RTI Team during the period September 1, 1974, to August 31, 1975.

New Problems Accepted	*40*
Problems Rejected	*0*
Problems Inactivated	*27*
Problems Reactivated	*2*
Total Problems Currently Active	*57*
Preliminary Problem Statements Prepared	*40*
Problem Statements Disseminated	*1*
Responses to Problem Statements	*7*
RDC Computer Searches Initiated	*14*
Impacts	*3*
Potential Technology Applications	*9*
Technology Applications	*5*

A description of currently active problems categorized by health area is attached as Appendix B.

4.0 APPLICATIONS ENGINEERING PROGRAM

Selected problems have been accepted for implementation of technology under the Applications Engineering Program. In the program, the technology is actually implemented by NASA. Activities for these three problems are presented in the following summaries.

PROBLEM DU-74 *Testing of Neuropathic Patients*

A system originally designed to measure pilot performance has been adapted for the study of neuromuscular disorders. Such disorders may result in the loss or impairment of muscular control. Therapy strives to train patients to improve the degree to which they can regain voluntary control over their muscles. This instrument represents an attempt to devise an electro-mechanical device which presents a manual tracking task and objectively evaluates the accuracy with which the task is accomplished. The RTI September 1973 - August 1974 final report presented a picture of the device on page 51. The device has been used by patients in tracking tasks for evaluation of muscle control. Presently, the device is at Langley where the electronics of the evaluation analog computer are being replaced by integrated analog circuits in order to effect an order of magnitude reduction in size. It may be possible to reduce the size of the complete apparatus to a portable size which can be delivered to the bedside of patients. A transfer report will be written when the device is back in use at Duke University. If the size reduction can be satisfactorily accomplished, the complete device may have commercial potential for rehabilitation training and evaluation.

PROBLEM UNC-73 *Image Intensifier for Microscopes*

The human disease-producing micro-organism, Mycoplasma Pneumoniae, is responsible for about half of all pneumonia occurring during adolescence and young adulthood. Basic research to identify a vaccine to combat this micro-organism is being conducted. This research uses the technique of immunofluorescence microscopy.

Immunofluorescence microscopy takes advantage of the phenomenon of fluorescence to locate and quantitize a micro-organism present in a tissue specimen or culture. A fluorescent dye is attached to an antibody. The tagged antibody attaches itself to a specific antigen which is on the disease-producing micro-organism. A tissue specimen containing the antigen is then illuminated with ultraviolet light while being examined under a microscope. The fluorescent dye gives off tiny amounts of light, thus revealing the location and quantity of the micro-organism present.

Since the specimen is constantly changing, a record is made by photographing the specimen through a microscope. Polaroid black and white film

having a film speed of ASA 3000 is used. Unfortunately, the results are not altogether satisfactory. Illumination of the specimen is limited because excessive light burns out the fluorescent dyes. The limited lighting requires long exposure times, but the length of exposure is limited because the fluorescent dye has a relatively short half-life. As a result very little detail other than the fluorescence can be caught on film.

Mr. Wayne Chen of Goddard Space Flight Center (GSFC) suggested the use of a special image intensifier used in NASA astronomy photographic work. The image intensifier is mounted in a 35mm camera and provides an apparent thirtyfold increase in film speed. It has been used extensively and very successfully by Mr. Larry Dunkelman of GSFC.

The problem originator discussed the technique with Mr. Dunkelman and Mr. Chen, and plans were made to evaluate the proposed solution. Using a NASA camera with an image intensifier, several laboratory evaluations were conducted. Photographs usually requiring time exposures of 2 to 6 minutes were obtained in less than 15 seconds. Although negatives of sufficient quality to provide useful data were obtained, there was degradation of the image. It was believed that a later version of the image intensifier, using more advanced fiber optic technology, would largely correct the degradation problem. An order was placed for a later version of the image intensifier,and delivery of that unit is expected in August 1975 with laboratory evaluations scheduled to begin upon receipt of the intensifier.

PROBLEM VAM-17 *Automated Stereo Photographic Mapping*

One in every 600 to 700 children is born with a cleft of the lip and/or palate. Extensive experience at correcting this deformity and its related dental and speech problem indicates that with the proper attention the cleft lip and palate child can be expected to be no different from other children.

An infant with a cleft of the lip and/or palate has the potential for growing and developing normally. Although a wide cleft of the lip and palate may be present at birth, the two separate portions of the palate can still grow and develop normally. The lip is often repaired first, usually during the first month or when a child reaches a certain weight. The soft palate can be repaired at the same time as the lip,although many surgeons prefer to do it later. Timing for closure of the hard palate cleft varies greatly. It will be determined after consultation with the orthodontist and a careful study of the palate size and form. There is no such thing as the only way to surgically close the cleft of the lip and/or palate,nor will the children with the same defect be operated on at the same age. Every face, even with the same type of cleft,will grow differently. It is the important factors of when and how the face changes that influence the surgical

decisions. In order to assess the changes that take place in the palate and the lip as a result of growth and/or corrective procedures, it is common to make a series of plaster casts of the child's palate and lip. Important quantitative information concerning the nature of the deformity has been obtained by the problem originator through stereophotogrammetric techniques,which have been employed to produce a contour plot of the plaster casts. A contour plot presents the surgeon with a more accurate description of the deformity and permits a more complete corrective procedure. Stereophotogrammetric techniques for contouring the plaster casts yield high quality results; however, since the method has not been automated, it is too time consuming and too costly to be applied to all but a few cases.

Dr. S. J. Katzburg of LRC, who is a specialist in optical systems, visited the problem originator. They discussed the possible use of an automatic focusing technique to obtain the desired information. The approach appeared very promising. Dr. Katzburg and members of his group designed and built a test system and verified the approach. An RTOP was submitted and approved, and plans are to develop and evaluate a prototype system.

5.0 CONCLUSIONS AND RECOMMENDATIONS

During this reporting period, nine potential technology applications and five technology applications were accomplished. Of the technology applications, three (DU-88, VAM-6, and VAM-26) were solved by personal contact with personnel at NASA Field Centers; one problem (NCI-4) was solved through response to a problem statement circulation; and one problem (TU-22) was solved by a literature search. From the set of nine potential technology applications, only one was solved by literature searching, while the remainder were solved by personal contact. The primary source of solution of these problems was direct interaction between NASA personnel and Biomedical Application Team personnel. This fact continues a trend that has been evident for the past 4 years--direct interaction with NASA personnel and problem statement circulation routinely have accounted for approximately 90 percent of the solutions to problems, with about 10 percent of the problems being solved using the computerized literature search. Because of the Team's awareness of the productivity of direct contact with the Field Centers (compared to information searching), a tendency exists to neglect information searching as a tool. Since this tool can be used at a very nominal cost, it must not be neglected. It is anticipated that direct contact will remain the primary source of solution for the Team in the future, but increased emphasis will be placed on information searching.

In order for a technology application to be accomplished, implementation of the technology must occur. The means of implementation varies with each problem, but for the five technology applications reported during this period, the sources were expenditures of fund by the problem originator, NASA equipment loan, or applications engineering funding. Two of the technology transfers (VAM-6 and NCI-4) required expenditure of NASA applications engineering funds in order to accomplish the transfer. One transfer (TU-22) was achieved by funds from an NCI grant, while another (VAM-26) was accomplished by travel funds provided by Boeing Aerospace Company. The fifth transfer (DU-88) was accomplished through the loan of an item of NASA equipment.

One of the major strengths of the Biomedical Application Team program is the breadth of technology available throughout the nine NASA Field Centers. In order for the Team to achieve maximum production, close interaction with all the Field Centers is required. This broadens the base of technology available to the Team and enhances the probability of solution of a particular problem. During this reporting period, Johnson Space Center helped the accomplishment of two of the technology transfers (DU-88 and VAM-26) and Marshall Space Flight Center personnel cooperated in three of the transfers (TU-22, VAM-6 and VAM-26). NASA Headquarters provided the direction for solution of one problem (VAM-26), while the Jet Propulsion Laboratory proposed the solution and Goddard Space Flight Center assembled the apparatus for one technology transfer (NCI-4).

When a technology application has been accomplished, a problem has been solved for a single medical investigator. If this technology application is to have full impact on society, the technology should be available to other medical groups. This availability can be directly achieved if a manfacturer for the technology can be found. The problem of finding suitable manufacturers for completed technology applications is a major one which the Team has attacked in two ways. One way is direct interaction with certain industries, and the other is through the formation of the Aerospace Technology Committee of the Association for the Advancement of Medical Instrumentation. Through these activities, the Team has learned that it is extremely difficult to approach a large company with a prototype device with the expectation that the company will eventually manufacture the device. Efforts in this direction have largely failed. The major interest comes from the small entrepreneural companies that are aggressively seeking new product opportunities. In the discussions of the Aerospace Technology Committee, many lessons have been learned about the philosophies of companies in marketing new products in the medical device area as well as in regard to the interest in these companies in the NASA Technology Utilization Program. Because of the necessarily small size of the Committee, the data base for this information is small but should be expanded to add reliability to the information. The Team recommended that a national survey of medical device manufacturers be conducted in order to expand the data base in regard to this problem area.

In response to this recommendation for a national survey of manufacturers, NASA Headquarters authorized the RTI Biomedical Application Team to conduct such a survey. The Biomedical Application Team enlisted the help of the RTI Statistical Group for the design, execution, and analysis of the survey. The survey was submitted to NASA Headquarters for approval, and then forwarded to the Federal Office of Management and Budget for approval. Due to some delay in securing the approvals, the timetable for the survey has been set back by several months. A request has been made through the contract monitor to adjust the time schedule for the survey to allow for this delay. The anticipated completion date is now set for December 1975. The results of this survey will be compiled into a separate report and copies will be provided to all interested parties in the NASA TU organization.

The Biomedical Application Team at the Research Triangle Institute has continued to expand the base of problem activity throughout the Souteastern United States. In addition, a special emphasis has been toward initiating activity in the Northeastern United States with its high concentration of major medical institutions. During this reporting period, activities have been initiated with three medical institutions in the Philadelphia metropolitan area. Immediate plans call for activities to be initiated in the Boston area and in New York City. Active problems already are being handled in Baltimore.

"Space Technology for Medicine" is the theme of an exhibit which was recently installed in the F. G. Hall Aerospace Building of the North Carolina Museum of Life and Science in Durham, North Carolina. The RTI NASA Biomedical Application Team, which is based nearby at the Research Triangle Institute, commissioned the construction of the display cabinet for the museum as a permanent exhibit illustrating specific applications of NASA technology to medicine.

The display case contains five vertical panels. The central panel contains text, which describes the NASA Biomedical Application Team program. The other four vertical panels each contain an example of a transfer of NASA technology by the RTI Biomedical Application Team. The panels of the display are of a sky blue color with contrasting white lettering and text. The two manequins are individually illuminated from above by white fluorescent lamps situated inside the recesses of the display case (see figure 9).

The 30 x 60 foot room containing the display also contains several items of NASA hardware, including an instrumentation model of the Mercury capsule that was orbited with a champinzee aboard. Immediately to the left of the RTI exhibit is the corridor leading to the building's central geodesic dome room in which is situated a full-sized lunar landing module surrounded by a simulated lunar terrain.

Even though the museum and its associated zoo is less than 5 years old, its growth has been rapid, and over half a million people are expected to visit the museum in 1975. The aerospace section of the museum already can be described as being the finest display of space hardware and memorabilia outside of NASA.

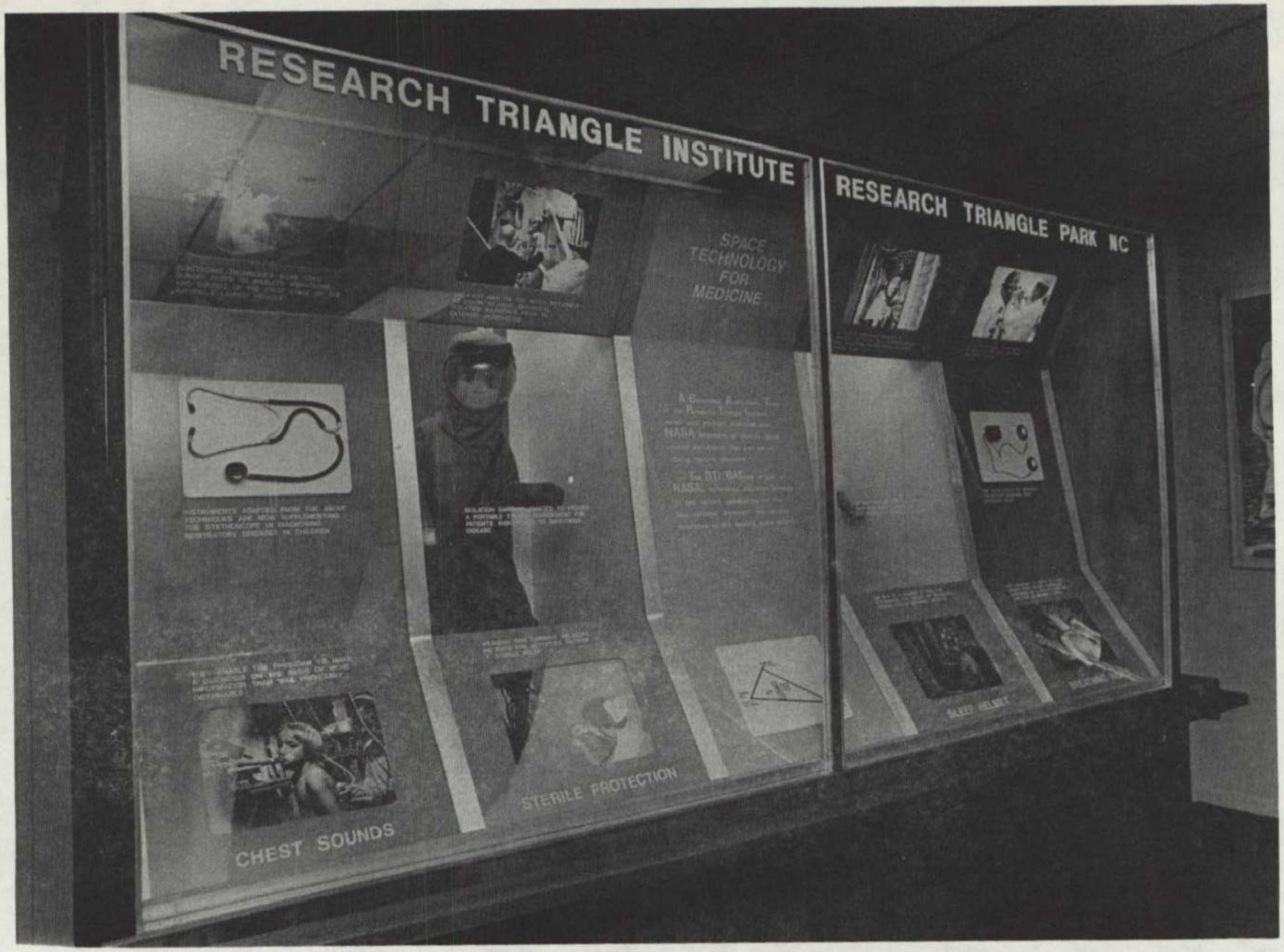

Figure 9. Display of RTI NASA Biomedical Application Team Accomplishments

APPENDIX A

PROJECT ACTIVITY SUMMARY

TECHNOLOGY APPLICATIONS ACCOMPLISHED

DU-88 *Respiratory Measurement in Epileptics*

NCI-4 *Controlled Rate of Freezing a Liquid*

TU-22 *X-ray Microplanigraph*

VAM-6 *Negative Pressure Chamber*

VAM-26 *Cancer Center Organization and Management*

POTENTIAL TECHNOLOGY APPLICATIONS IDENTIFIED

DU-94 *A Means of Accurately Positioning Tumors With an X-ray Therapy Device in a Minimal Period of Time*

JHU-4 *Relating BCG and Carotid Pressure Pulses*

LSD-1 *New Methods for Cleaning Teeth*

MISC-41 *Fire Protection in Paraplegic Homes*

TU-41 *Computerized X-ray Microtomography*

UNC-82 *Method for Measuring Villi Motion*

VAM-24 *Processing of Rapid Microfluorimetry Data*

VAM-28 *Sleep Study Monitoring System*

VAM-32 *Cardiology Information Presentation Techniques*

IMPACTS

DU-89 *ECG Telemetry Measurements of Physically Active Subjects*

TU-10 *Quantization of Heart Tissue Hardness*

UNC-85 *High Speed Remote Stirrer*

APPLICATIONS ENGINEERING ACTIVITIES

DU-74	*Testing of Neuropathic Patients*
UNC-73	*Image Intensifier for Microscopes*
VAM-17	*Automated Stereo Photographic Mapping*

CURRENTLY ACTIVE PROBLEMS AS OF AUGUST 31, 1975

PROBLEM NUMBER	STATUS CODE*	PROBLEM TITLE
DU-74	E	*Testing of Neuropathic Patients*
DU-90	B	*A New Type of EEG Electrode Featuring Ease of Preparation and Superior Operating Characteristics*
DU-91	B	*Submillimeter Differential Length Measurement Device*
DU-92	D	*Bone Mineral Measurement*
DU-94	B	*A Means of Accurately Positioning Patients' Tumors within an X-ray Therapy Device in a Minimal Period of Time*
HMC-1	B	*Automatic Cueing of Prerecorded Voice Recordings*
ICR-1	B	*Techniques for Minimizing the Time Necessary for the Application of Scintilltion Autography Techniques*
ICR-2	B	*Device for Repetitively Dispensing a Predetermined Weight of Granular Material with 0.02 Gram Accuracy*
JEF-1	B	*Electronic Circuit for Automatic, Continuous, Baseline Drift Correction*
JEF-2	B	*Electronic Instrumentation for Detecting and Quantifying Motion in Closed Circuit TV Pictures*
JEF-3	B	*Development of a Miniature, Portable, Multichannel Biofeedback Apparatus*
JHU-4	E	*Development of Computer Technology for Relating the BCG and Carotid Pressure*
LSD-1	E	*New Method for Cleaning Teeth*
MISC-25	D	*Micro-Connector for Magnetically Guided Catheter*
MISC-35	E	*Weight Reduction in Braces for Children*
MISC-36	D	*Reduction of Sound Level in Rooms Used by Groups of Mentally Retarded Children*

*See explanation of status codes at end of listing.

PROBLEM NUMBER	STATUS CODE*	PROBLEM TITLE
MISC-37	D	*A Means of Patient Manipulation Requiring Less Physical Strength*
MISC-40	E	*Storage Technique for X-rays*
MISC-41	E	*Fire Protection in Paraplegic Homes*
MISC-42	B	*Whole Body Movement Measurement*
MISC-43	B	*Electrode Fabrication Technique*
MISC-44	B	*Portable Clean Room*
MMRC-1	B	*Improved Design of Wheelchair Control Interfaces*
MUSC-1	B	*Survey of Quartz-Filled Composite Technology*
MUSC-2	B	*Verification of Vitreous Carbon Material for Use in Dental Implants*
MUSC-3	B	*Titanium Metal Sintering and Fabrication Techniques*
NCI-4	F	*Controlled Rate of Freezing a Liquid*
NCI-14	B	*Packing Design for Thermal Control of Drug Shipments*
NCI-15	C	*Prevention of Alcohol Leakage from Injection-Type Pharmaceutical Vials*
TU-41	E	*Computerized X-ray Microtomography*
UMISS-1	B	*Criteria for Selection of Computer Systems in Biomedical Simulation*
UMISS-2	B	*Fluid Mechanics Studies in the Artificial Heart*
UMISS-5	F	*Leg Brace Weight Problem*
UNC-66	D	*Determining Tissue Perfusion Adequacy*
UNC-71	F	*Finger Joint Flexor*
UNC-73	E	*Image Intensifier for Microscopes*
UNC-82	E	*Method for Measuring Villi Motion*
UNC-83	B	*Neonate Thermal Control for Use in Surgery*
UNC-86	B	*Evaluation of Pollution Effects*

PROBLEM NUMBER	STATUS CODE	PROBLEM TITLE
UNC-87	B	*Near Real Time Monitoring of Gas Concentrations*
UNC-88	B	*Improved Cooling Technique*
UNC-89	B	*Protein Separation*
VAM-21	B	*The Artificial Tendon*
VAM-22	B	*Artificial Teeth*
VAM-24	E	*Processing of Rapid Microfluorimetry Data*
VAM-25	D	*Mechanical-Energy Storage Device of Hip Disarticulation*
VAM-26	E	*Cancer Center Organization and Management*
VAM-27	D	*Contour Mapping of Head*
VAM-28	E	*Sleep Study Monitoring System*
VAM-29	B	*Hospital Facility Management*
VAM-30	B	*Computerized Patient Recordkeeping*
VAM-31	B	*Structural Analysis of Biological Tissue*
VAM-32	B	*Cardiology Information Presentation Techniques*
VAM-33	B	*Breast Cancer Screening Technique*
VAO-2	B	*Improved Artery Shunt Prosthesis*
WF-121	B	*Accurate Measurement of Input and Output Power From Ultrasonic Probes*
WWRC-17	B	*Redesign of a NASA Electrically Steered Wheelchair*

APPENDIX B

DESCRIPTION OF CURRENTLY ACTIVE PROBLEMS

(CATEGORIZED BY HEALTH AREAS)

(This description does not include those active problems previously discussed in Section 2 as technology applications, potential technology applications, or impacts or in Section 4 as an applications engineering project.)

HEALTH AREAS

REHABILITATION MEDICINE

PROBLEM MMRC-1 *Improved Design of Wheelchair Control Interfaces*

Many quadriplegics do not have adequate head movement control (e.g., those who have spasticity problems) to operate electrically-powered and steered wheelchairs reliably with the conventional joystick control interface. However, these people often do have tongue, voice, bite, and eye-movement control, and some control interfaces have been developed to take advantage of these few remaining functions. Natural coding is extremely desirable, since many physically debilitated individuals have little patience with devices that are not easily and readily usable. The FET dental pressure transducer array is difficult to sterilize and cannot be readily removed for eating. The FET array is amenable to natural coding, though, since the direction the tongue points can command the direction of wheelchair travel.

A literature search has been initiated.

PROBLEM VAM-25 *Mechanical-Energy Storage Device of Hip Disarticulation*

A prosthesis to replace the entire leg, including the hip joint, is called a hip disarticulation. In general these devices, which primarily use passive components, have three major sections: 1) a trunk socket in which the body rests, 2) a thigh section, and 3) a leg and foot section. Simple hinges join the three sections at the hip and knee. Optimum performance is obtained through the proper alignment of the prosthesis sections. This requires several very sensitive mechanical adjustments. However, at best, the resulting gait is greatly distorted.

In walking, the major source of gait distortion occurs as the prosthesis swings forward. As a normal leg swings forward, it is bent at the knee and the hip, thus insuring that the foot clears the ground as the foot moves forward for the next step. However, the prosthetic leg, during its swing forward, is straight (not bent at the knee or hip). Thus, to have the prosthetic foot clear the ground, the patient must go through several gait distorting maneuvers. Some small energy storage device is needed that would store energy during part of the stride and release this energy as the toe is lifted from the ground. The released energy would move the thigh section forward, rotating it approximately 20° about the hip-hinge axis. The rate and amount of this motion must be closely controlled. The amount of force required to produce the desired thigh motion will depend on the way the energy storage device is attached to the prosthesis. However, the lower two sections of the prosthesis have a total weight of approximately 4 pounds, the thigh section weighing 1.5 pounds and the lower-leg section weighing 2.5 pounds.

The desired device must be reliable, durable, and must not weigh more than 1.5 pounds (preferably less). It must not interfere with the prosthesis assuming extreme positions (e.g., sitting), but must, as the prosthesis foot leaves the ground, move the thigh section forward, rotating the thigh section approximately 20° about the hip-hinge axis. The amount of forward motion imparted to the thigh section must be closely controlled. Too much motion will prevent the proper prosthesis alignment needed for the next step, and too little motion will not solve the gait-distortion problem.

Several suggested solutions were received in response to a circulated problem statement. Each suggestion was thoroughly studied. The problem originator selected the suggestion submitted by Mr. Wilbur C. Vallotton of Ames Research Center. Mr. Vallotton visited the problem originator and discussed the problem in more detail. It is now planned for Mr. Vollotton to work closely with a San Francisco hospital and the problem originator in developing a functional prototype that will be evaluated at several rehabilitation centers.

DETECTION AND TREATMENT OF HEART DISEASE

PROBLEM VAO-2 *Improved Artery Shunt Prosthesis*

Prosthetic grafts may be used to replace damaged arteries. The problem originator is presently concerned with grafts of the femoral artery which, after implantation, cause some problems in clotting on the downstream end of the vascular graft. It is suspected that this clotting is caused by a complex interaction of blood flow conditions in and around the graft, graft elasticity, porosity, length, taper, graft surface-blood interface, and surgical insertion technique. A systems analysis to define these interactions and to design an optimal non-thrombogenic graft would be one way to approach this difficult, unsolved problem. Prosthetic grafts with superior patency must be developed, since over 20 percent of the graft implant patients do not have veins that are suitable for the bypass (the veins are too small or diseased), and it is undesirable to sacrifice the vein function in any case. A means of reducing clotting in this region is required.

A literature search has been completed. Personnel at the Jet Propulsion Laboratory have replied to the preliminary problem statement with a proposal for computer modeling of the flow dynamics in and around the typical graft. Funding of the proposal has not been accomplished.

DETECTION AND TREATMENT OF CANCER

PROBLEM VAM-29 *Hospital Facility Management*

More than 20 major cancer treatment centers are currently being established throughout the United States. They will utilize state-of-the-art treatment techniques with a major emphasis placed on speed of treatment. Hopefully, in the cancer center the combined skills of the hospital (surgical, radiology, etc.) will be jointly focused on the patient much as is done in the health-screening clinic. This approach appears vital to successful cancer treatment. Unfortunately, the number of patients involved is large, and each patient will probably require the use of several of the laboratories as well as other hospital facilities. Coordinating this usage becomes practically impossible. As this coordination effort fails, certain laboratories will become overloaded while others are unused. Treatment delays will result, and these delays can completely defeat the concept of the Comprehensive Cancer Center.

The problem originator has been given the responsibility of developing a computerized facility (laboratory, radiology, etc.) management program which would be part of an overall cancer center management scheme. Also included in this scheme would be computerized patient record keeping (covering only core data) and laboratory reporting. He inquired if NASA had done any work which might assist him in developing this computerized management system.

A proposal was submitted to the problem originator suggesting that the computerized facility management system developed by IBM for Kennedy Space Center might be directly applicable. This suggestion is under evaluation.

PROBLEM VAM-30 *Computerized Patient Recordkeeping*

More than 20 major cancer treatment centers are currently being established throughout the United States. They will utilize state-of-the-art treatment techniques with a major emphasis placed on speed of treatment. Two important objectives of this program will be the accurate clinical evaluation of the new treatment techniques, and the assessment of possible trends in the incidence of certain types of cancer. The necessary information for the accomplishment of these two objectives will be contained in the patient's medical record. Computerization of the patient medical record would greatly simplify extracting of this information. Unfortunately, in spite of considerable effort, little success has been realized in computerization of patient records. However, the difficulties which have prevented success in the hospital may be eliminated in the Comprehensive Cancer Center setting. As an example, the interest is focused not on the

entire medical record, but rather on an abbreviated form referred to as "core chart data." Other advantages are the existence of both a standard language and a standard disease staging. Combined with these advantages are the presence of medical personnel who are very conversant with the advantages and limitations of the computer.

The problem originator has been given the responsibility of developing a computerized patient record which will maintain core data on each patient. He inquired if NASA had developed any computerized recordkeeping systems that might be applicable.

A proposal was submitted to the problem originator which suggested that the KSC (IBM developed) Saturn Information Reporting System (SIRS) was directly applicable. This proposal is currently under evaluation.

PROBLEM VAM-33 *Breast Cancer Screening Technique*

Early detection is vital to the successful treatment of breast cancer. Several new techniques have provided significant improvement in the ability to detect breast cancer. Unfortunately, the new techniques are limited in number, are costly both in time and money, and require very skilled personnel to interpret the results. This drastically limits the number of women who can benefit from these techniques. Thus the general prognosis for breast cancer has shown little or no improvement over the past 40 years.

The problem originator is extremely skilled in the use of all forms of mammography. He asked if NASA had developed any pattern recognition techniques that might be combined with existing mammography techniques to produce a rapid breast cancer detection system. Hopefully, this technique could screen large populations of those women who fall into high risk categories as well as of those women having breast cancer. He believed that mammography's ability to detect differences in symmetry between the two breasts could be automated to provide the desired breast cancer screening system.

A mammogram appears as a positive of an X-ray (the more opaque parts of the breast appear as darker spots on the film). The resulting spots on the mammogram can be from fibrous tissue, tumors, vascularization, etc. The difference between breasts in the size, location, and arrangment of these spots is the radiologist's diagnostic tool. Of course, other techniques such as thermography and X-ray can be used to provide additional information.

The problem originator visited KSC and met KSC personnel involved in image enhancement and pattern recognition. Possible use of the IMAGE-100 is being considered.

ECOLOGY

PROBLEM UNC-86 *Evaluation of Pollution Effects*

The Environmental Protection Agency (EPA) has established a laboratory facility at the University of North Carolina. A major objective of this facility is to define the physiological and neuromuscular control effects of various levels of inhaled pollutants. Included in the laboratory are several thoroughly instrumented environmental chambers which are supported by an extensive computer facility. Subjects will be placed in these chambers and directed to do various tasks while numerous measurements are made. This will be done under both normal atmospheric and various levels of pollutants. Based on the results, it is hoped that the EPA personnel will be able to quantitize the pollutant effects.

The problem originator is responsible for the area of neuromuscular control effects. He asked if NASA had developed any techniques for evaluating an astronaut's neuromuscular control. He was especially interested in techniques that would provide a mathematical measure of the individual's ability.

He was given material that describes the Langley Research Center pilot modeling system, a system that was used to study the pilot-aircraft control system interface. Material describing the Complex Coordinator is also being forwarded to the problem originator.

PROVISION OF MORE/BETTER MEDICAL/PARAMEDICAL PERSONNEL

PROBLEM HMC-1 *Automatic Cueing of Prerecorded Voice Recordings*

The task of providing supplementary lecture material to medical students and of providing tutoring material for exceptional students has led to a request for a means of reducing the time/labor in preparing these presentations. The preliminary investigations of the problem with NASA field center personnel led to the concept of microfiche as being the most economical means of information distribution. The fiche can be easily prepared in hundreds of copies from any source material which can be photographed. The individual frames of the fiche can be formatted into a programmed learning sequence if desired. With the more complex fiche frames, an audio narration would be desired to explain details of complex microscope photographs of cytological or histological nature. In order to accompany the random nature of the programmed visual aid, the audio aid must also be capable of random access to a set of individual narrations. It was thought that NASA technology could be utilized in adapting an existing system for identifying NASA analog tape records on lengthy analog tapes to the indexing of

individual narrations on tape recordings. If such a system could be devised, low cost cassette tape equipment could be utilized with a savings in the investment required for the system. In fact, it was hoped that the system could be configured so that each medical student could possess his own microfiche reader and tape player.

IMPROVED SURGICAL PROCEDURES

PROBLEM UNC-83 *Neonate Thermal Control for Use in Surgery*

Thermoneutral temperature is the skin temperature, about 36°C, of an infant up to 4 weeks old at which metabolism is at a minimum. Small variations in this temperature produce a significant increase in oxygen consumption. Since respiratory difficulties are not uncommon in neonates, a thermal insult could easily be fatal.

Body heat loss can occur by convection, radiation, evaporation and conduction. While these losses can be closely controlled in a nursery, their control in surgery becomes difficult. Thus surgery is, on some occasions, especially hazardous because of the added risk of temperature-induced metabolism changes.

Efforts to solve this problem include heated operating tables, elevated room temperature, and infrared radiation sources. Each has undesirable features. In the use of a heated table, the area of contact with the neonate is limited to small patches on the back of the head, shoulders, buttocks, and heels. Because of sensitive skin and the small contact area, neonates have actually been burned. Elevated room temperature results in poor working conditions for the surgical team. In the use of infrared radiation, surgical personnel block the radiation while working over the neonate.

A device is needed that is capable of regulating a patient's skin temperature at 36°C $\pm$ 0.2°C during surgery. It must be adaptable to patients of different sizes and to varying surgical procedures.

Dr. Bill Williams, Ames Research Center, suggested that the NASA developed water cooled material used to provide the astronaut thermal protection might be applicable. He has proposed a system and is currently developing a prototype for evaluation.

PROBLEM VAM-27 *Contour Mapping of Head*

Surgical techniques to repair severe congenital facial abnormalities have been developed. They involve sectioning of the skull and relocating and reshaping various facial features (e.g., nose, mouth, eye sockets). Through these techniques, patients who were previously hopelessly disfigured and doomed to a nightmarish existence now have a hope for a reasonably normal life.

Contour maps are used in conjunction with data from several sources to determine the best surgical procedure and to monitor the recovery process. The problem originator needs an easy-to-use, rapid, and minimally traumatic means of obtaining contour maps of the front, rear, side, and top view of the human head. The desired contour line interval is 2.5-mm with accuracies of $\pm$1-mm. These maps are currently obtained through standard stereophotographic map-making techniques, which are slow and expensive.

Dr. Yoram Yakimovsky, Jet Propulsion Laboratory, met with the problem originator. He suggested the use of a TV system for obtaining the desired points. Based on the problem orginator's enthusiastic response, Dr. Yakimovsky submitted an RTOP proposal which was approved and funded. Plans are for Dr. Yakimovsky to meet with the problem originator in late August to finalize the design approach.

BASIC MEDICAL RESEARCH PROBLEMS

PROBLEM DU-90 *A New Type of EEG Electrode, Featuring Ease of Preparation and Superior Operating Characteristics*

The problem originator is trying to establish an EEG electrode system which is simple to install on the patient, but which exhibits low impedance, low offset voltage, and low rate of offset voltage drift. The electrodes would be used in research projects ranging from testing the simulated automobile driving of young and old drivers, to characterizing the onset of drowsiness during simulated automobile driving. Because most of the research projects involve the screening of many subjects, it is desirable that the EEG electrodes can be quickly applied. The researcher has been provided with complete information concerning the NASA Frost electrode cap and he has also been provided with extensive literature from the NASA sources concerning electrode systems of various types. Several of the different electrode types are being examined by the researcher and further progress on this problem will await the completion of his evaluation.

PROBLEM DU-91 *Submillimeter Differential Length Measurement Device*

The problem is to monitor the submillimeter displacements of a very small diameter metal rod connecting the free end of a single muscle strand to an electro-mechanical "muscle puller" device during medical biophysical experiments. The muscle puller exerts rapid translation motions to the free end of the slightly stretched muscle fiber. As a result of these preprogrammed motions, the force exerted by a muscle fiber can be studied at different phases of the contraction cycle. However, in order to

accurately control the very fast motion of the muscle puller device, a feedback loop must be designed for the driver electronics of the muscle puller. The feedback loop would compare the amplified voltage from the submillimeter displacement transducer with the programmed analog control voltage in order to force the actual motion of the muscle puller to conform with the desired motion. The submillimeter displacement transducer of required dynamic response and sensitivity is the only item lacking for the experiment.

Two responses to the preliminary problem statement came from the Langley Research Center. Dr. G. L. Gregory and Mr. H. G. Fuller both suggested the use of linear variable differential transformers to sense the translational motion.

The RTI literature search listed several precision displacement measurement instruments of high accuracy, but with rather slow dynamic response. However, there were two references which were of promise. Upon ordering the documents, both instruments seemed to be applicable. One, a simple two-fiber optical displacement sensor came from the open scientific literature. The other, concerned with eddy-current testing and motion sensing, came from NASA literature. The researcher will evaluate all three suggestions.

PROBLEM ICR-1 *Techniques for Minimizing the Time Necessary for the Application of Scintillation Autography Techniques*

Nucleic acids of cancer-causing viruses can be studied by fracturing the long DNA or RNA chains into subunits through the application of one of the newly discovered "fracture enzymes". Each fracture enzyme breaks the chain at a particular chemical bond. Thus each enzyme gives a different set of fragments. Gel electrophoresis methods separate the fragments resulting from application of a given fracture enzyme. The intact nucleic acid chain is prelabelled with a single type of radioactive nucleic acid. In order to assay the resulting radioactivity pattern in the electrophoresis bands, autography is the method of choice. Because tritium is used as the radioactive species, the radiation is not strong enough to penetrate through the gel and to a film. Therefore, a scintillator molecular compound, called PPO, must be dispersed into the gel. The radioactive particles strike the dispersed PPO and cause it to emit light flashes which can then be recorded by photographic film placed over the gel. The problem consists of investigating whether there is a better way for tritium detection. It takes 24 hours to load the gel with PPO and 24 hours to record the scintillation pattern. Because electrophoresis is a technique that is widely used in medical research, biochemistry, and physiology laboratories, a simple, rapid method for tritium scintillation autography would certainly find widespread use.

PROBLEM JEF-1 *Electronic Circuit for Automatic, Continuous, Baseline Drift Correction*

Involuntary eye movements during sleep are studied by scientists in the hopes of relating the eye movements to the several stages of sleep in humans and animals. Early childhood development of neuromotor coordination can be studied by the monitoring of the development of synchronism of rapid eye movements. Because the eye movements are detected by electrodes on the surface of the skin about the eye, the amplitude of the signals are below 100 microvolts. As a result, considerable amounts of extraneous physiological signals are routinely detected in addition to the desired signal. The baseline of each recording electrode does not show long time dc stability. Amplitude discriminators cannot be used to detect the rapid eye movement voltage pulses. The problem is to devise an electronic circuitry which will permit automatic detection of the voltage pulses instead of the subjective analysis of chart recordings, as is now done.

Field center replies to the preliminary problem statement suggested the use of bandpass active filters which are rather easily implemented with integrated circuit operational amplifiers. Also, a literature search turned up a circuit for an operational amplifier which adjusts itself for the instantaneous voltage level of the input. Both of these possible solutions are being studied by the researcher and implementation will await his evaluation.

PROBLEM VAM-31 *Structural Analysis of Biological Tissue*

In walking or standing, the bones of the lower leg are the main load-bearing structure. For the unfortunate individual who suffers a break of one or both of these bones, some alternate load-bearing structure must be provided (crutches or a heavy plaster case with a walking bumper attached to the bottom of the cast). Recent research has been exploring use of the soft tissue of the lower leg as a load-bearing structure--a process termed "fracture bracing." In this process, a lightweight rigid container encompasses the leg thus creating a column of soft tissue on which the weight can be supported. In addition, this process immobilizes the bones. Researchers at the University of Miami have had amazing success with this new treatment technique.

The space between the two bones of the lower leg is filled by a membrane called the "interosseous membrane." While it is generally held that this membrane plays a very minor role, Miami researchers, during the fracture bracing studies, have observed very basic changes in the membrane structure as a result of fracture healing. It is their opinion that this membrane plays a very important role in the healing process. In order to study and to evaluate this role, they are developing a mathematical model of the structural characteristics of soft biological tissue. This model

will be expanded to simulate this membrane. The problem originator asked if any structural analysis and modeling techniques were available in NASA that might be applicable.

The possible use of NASTRAN is being considered. The problem originator has studied the available literature, and he has consulted with several users of NASTRAN.

OTHER, MISCELLANEOUS

PROBLEM DU-92 *Bone Mineral Measurement*

The loss of bone mineral causes significant deterioration in the mechanical properties of the bone. Several diseases can affect this loss including osteoporosis, solid tumors, and inactive use of the body. Periods of extended bed rest, such as during long term illness, can result in mineral loss from the bones of the body. The problem originator has long been active in the study and prevention of mineral loss from bones in patients requiring long periods of bed rest. He has been hampered, however, in that there is no excellent method of measuring bone mineral loss. Several methods of detecting bone mineral loss has been developed, and one of the most common is the use of density measurements of a conventional X-ray. However, improvements in accuracy in this technique are needed. Other methods have been developed which allow measurement only of certain bones such as in a digit or in the *os calsis*. A new method is needed which will allow the measurement of the long bones with great accuracy.

An information search revealed the use of a monoenergetic isotopic photon source on the Apollo missions for measurement of bone mineral loss following space flight. The technique was developed by Dr. John Max Vogel who is now at the University of California at Davis. Communication with Dr. Vogel revealed that he has three models of the bone analyzer which he lends to scientists for periods of 90 days. However, the problem originator is interested in using the instrument in a rehabilitation survey of bed rest patients and would need the instrument for a period of at least one year. Negotiations are continuing for the extended loan of the instrument. Probably a proposal must be written by the problem originator (explaining the intended long-term use of the instrument as a rehabilitation monitor) and submitted to Dr. Vogel before the loan can be achieved.

PROBLEM ICR-2 *Device for Repetitively Dispensing a Predetermined Weight of Granular Material with 0.02 Gram Accuracy*

Laboratory animal nutrition studies have proven that certain types of cancer can be controlled completely by the diet. These studies measure the

type and quantity of diet presented to the animals. The task of preparing hundreds of food bottles for mice and rats can be considerably simplified if a precisely known weight of food could be dispensed into the individual bottles for each experiment. The problem consists in finding an apparatus which can automatically dispense 10.00 grams of food into each bottle. The consistency of the food resembles that of domestic brown sugar. The accuracy of the dispenser should be $\pm$ 0.02 grams. The device should be able to fill at least 500 bottles per day. The laboratory has available a digital scales with digital output lines (BCD). This scale could be made an integral part of the automatic dispenser system.

An alternative to the automatic dispenser is a system whereby each individual bottle could be marked by letters, symbols, or both, so as to uniquely identify the bottle during its lifetime. No labelling system has been found by the researcher which can withstand the rigors of repeated steam sterilization cycles and the handling to which the bottles are subjected.

PROBLEM MISC-43 *Electrode Fabrication Technique*

The problem originator has developed a long-term, implantable, all metal needle pH electrode that is completely contained in an 18-gauge hypodermic needle. It consists of a palladium hydrogen-sensing surface and an Ag/AgCl reference surface. However, he has encountered a problem in its manufacture which considerably limits the electrode's availability. Working through a 0.015 inch x 0.25 inch slot in the needle wall, he must remove insulation (epoxy layer and Teflon tube) in order to expose a small portion of the reference electrode. He can do this, but his methods (using a hot wire or a sharp surgical scalpel) are slow and frustrating. He wonders if either a simpler technique to cut this hole, or some other fabrication technique that would eliminate the problem, is available.

He currently follows these steps in fabricating the electrode: (1) Etch a 0.015 inch x 0.25 inch hole in the needle wall about 0.5 inches from the needle point. (Note: This hole must be on the side.) (2) Vacuum deposit a palladium coat on the needle's external surface. (3) Place a Teflon-coated silver wire in the needle lumen. (4) Dip the end of the needle in epoxy and allow the epoxy to be pulled up inside the needle via capillary action to seal the needle end and to lock the silver wire in place. (5) Expose the silver wire through the etched hole. (6) Condition the exposed silver surface. (7) Connect electrical leads and coat the connections with potting compound. If some method was available for forcing a slightly over sized Teflon-coated silver wire into the needle, the hole through the Teflon could be cut before the electrode is assembled. This would considerably simplify the electrode fabrication. Regardless of the technique used the resulting electrode must be made of biocompatible materials. The needle end must be sealed in such a manner to prevent body

fluids from penetrating between the needle case and the silver wire. The same quality seal is required at the reference electrode site.

Specialists in manufacturing techniques at LRC have been consulted.

PROBLEM MISC-44 *Portable Clean Room*

Because of skin loss, the severely burned patient is extremely vulnerable to heat and fluid loss as well as infection. As a result, clean room technology, with its laminar air flow and controlled environment, has greatly improved the severely burned patient's chances of survival. However, this equipment is bulky and does not lend itself to being moved. Thus, if a patient must be moved to a new site, in order to get a special type of care, he must be removed from the protection of the clean room. Some type of portable clean room system is needed which can be brought into the clean room, have the patient placed in it, and can be transported via ambulance to the new treatment site.

Two suggested solutions, one from Mr. William H. Kinard, LRC, and one from Mr. Dennis Peterson, KSC, were received. The problem originator was interested in both. The suggestions were also discussed with a clean room manufacturer who had expressed interest in commercialization of the resulting portable clean room. The manufacturer is now preparing a proposal for building a prototype for evaluation.

PROBLEM NCI-14 *Packing Design for Thermal Control of Drug Shipments*

Experimental drugs prepared by the NCI pharmacy and shipped by them to all parts of the world experience deterioration when exposed to temperatures over 55°C. The pharmacist has provided two shipment boxes containing sample drugs to provide an illustration of the present inadequate method of packaging the drugs for air freight shipment. Langley Research Center has these sample boxes at the present time and is evaluating the packaging system for the purpose of determining whether a different method of packaging would be of value or whether more modern space-age materials should be used. It is conceivable that the problem may be solved by utilizing reflective mylar sheets as radiation/moisture barriers and styrofoam flakes as the principal insulation.

PROBLEM NCI-15 *Prevention of Alcohol Leakage from Injection-Type Pharmaceutical Vials*

The National Cancer Institute pharmacy sends small volumes of sterile ethyl alcohol along with shipments of powdered drugs so that the drugs may be resuspended in the alcohol fluid and diluted with sterile water immediately

before use. However, a certain percentage of the alcohol vials have been observed to leak during air freight shipment. Such leakage is a serious problem because the exact volume of alcohol must be maintained in order to prepare the proper drug dilution.

Kennedy Space Flight Center and Langley Research Center have both submitted similar suggestions for the solution of the alcohol leakage problem in response to the circulation of problem statements. The literature survey did not provide solutions.

This problem was submitted to NASA Headquarters in response to their request for problems to submit to the NSF DOD Consortium.

PROBLEM UNC-87 *Near Real-Time Monitoring of Gas Concentrations*

Anesthesia is a very critical part of surgery. If the anesthesia is insufficient, the patient is subjected to an excessive amount of trauma, and if it is excessive, the patient can easily be killed. Defining the area between these two extremes--that level of anesthesia that is considered to be satisfactory--is left largely to the judgment of the anesthetist. In an effort to provide a more precise definition of what is a satisfactory level of anesthesia, the problem originator is attempting to measure in surgery the level of concentration of six different gases (CO_2, O_2, H_2O, Halothane, Fluorthane) in the patient's inspired and expired air. Unfortunately, his measuring system requires taking bulky samples of air and processing them through the laboratory. This limits the number of samples he can take and also introduces a significant time delay before the results are available. He asked if there was a method available, which could provide near real-time monitoring of these gas levels.

Langley Research Center personnel suggested the use of a mass spectrometer. The problem originator visited LRC and discussed the problem in more detail. It is now planned to adjust a mass spectrometer and evaluate the feasibility of the suggestion.

PROBLEM WF-56 *A Fluid Pressure Calibration System*

This problem, which was described as a technology transfer in the RTI report of September 1971 - August 1972, pages 26-29, has been reactivated at the request of Dr. Ernie Harrison at the Mississippi Methodist Rehabilitation Center, Jackson, Mississippi. The device has been in use at the Bowman-Gray Medical School for about three years.

Dr. Harrison now has the device and will generate engineering drawings from it and will also draw accurate electronic circuit diagrams. There is a possibility that the device can be commercialized, so it is essential to have the proper documentation prepared.

APPENDIX C

NEW PROBLEMS ACCOMPLISHED DURING FOURTH QUARTER

(July - August)

PROBLEM JEF-2

PROBLEM TITLE: "Electronic Instrumentation for Detecting and Quantifying Motion in Closed Circuit TV Pictures"
DATE OF PREPARATION: June 27, 1975
INSTITUTION: Jefferson Medical College, Philadelphia, PA
DEPARTMENT: Psychiatry and Human Behavior
INVESTIGATOR: Dr. Edward Gottheil
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: Electronic instrumentation which can A) process the video signal from a closed-circuit TV camera so as to divide the image into eight or more sectors, B) detect any motion which occurs in the image field of any of these sectors, and C) quantify the magnitude of motion which occurs in the sectors.

HEALTH AREA: 6 REQUIREMENT: B

BACKGROUND: The problem originator is a practicing psychiatrist who is interested in the study of body movements and in the relating of these movements to psychological and emotional states. For example, during psychoanalysis sessions, patients with deep anxiety may exhibit body movements which can be directly correlated to the intensity of the anxiety. Even though the body movements of tapping the foot, drumming the fingers, and bitting the fingernails are classically associated with anxiety behavior in humans, there are many other possible types of body movements which, once detected and related to the anxiety state, may serve as clues to the psychiatrist in his work with the anxious patients. The identification of the body movements characteristic for each patient is sometimes a difficult task for the doctor because each patient has his own specific set of movements. Therefore, the doctor is especially interested in developing a system for detecting motion of various parts of the body of the patient during interview sessions, and then quantifying these motions in order to have an estimate of the types and frequency of body motions. With this information, the doctor can evaluate the current state of patient's anxiety and modify the treatment protocol so as to be most effective in relieving the patient's anxiety.

CONSTRAINTS AND SPECIFICATIONS: At the present time, the doctor has a closed-circuit TV camera and video tape recorder which he uses infrequently to record his psychotherapy sessions. The doctor envisions a solution to his problem of identifying and quantifying body movements through the use of the TV system if the following could be accomplished: sector the TV image electronically into eight or more rectangular sectors and have the ability to electronically sense motion in each of the sectors of the image. When the TV signal contains an image of the patient, either seated or on a couch, any motion of the patient's body would be transmitted in at least one of the sectors of the TV image. An electronic circuit could then be devised to tally the frequency and magnitude of motion in each of the sectors.

After the patient's characteristic body motions had been identified and after therapy sessions had resulted in lower frequency of body motion, an especially attractive feature for the doctor would be the capability to monitor body motion in real time, i.e., during the psychotherapy session.

OTHER COMMENTS: The doctor is rather knowledgeable about gait analysis and has been impressed with the potential for TV analysis of body motions in research and now is trying to apply video techniques to clinical medicine.

PROBLEM STATUS: Literature search proceeding in the studies of techniques for sectoring TV images and for detecting motion within TV image fields.

PROBLEM JEF-3

PROBLEM TITLE: "Development of a Miniature, Portable, Multichannel Biofeedback Apparatus"
DATE OF PREPARATION: June 27, 1975
INSTITUTION: Jefferson Medical College, Philadelphia, PA
DEPARTMENT: Psychiatry and Human Behavior
INVESTIGATOR: Dr. Stephen C. Padnes
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: Development of a multichannel biofeedback instrument for use in the monitoring of the human relaxation state and for calculating a patient's responses to physiological and psychological stressors.

HEALTH AREA: 6 REQUIREMENT: B

BACKGROUND: When faced by recurring stresses, an individual must repeatedly mobilize his physical and mental resources. Such responses involve sympathetic nervous system activation and elevated muscle tension. Both of these alarm reactions contribute to preparing the individual to respond to threats and challenge. Individuals who are frequently forced to mobilize themselves to meet stresses are likely to lose their ability to execute the opposite response, i.e., to shift back into the relaxed state in which bodily recuperation normally occurs.

Biofeedback techniques have been employed by the researcher to modify the patient's reaction to psychological stress and help the patient produce the low arousal state. Recently, experimental evidence has shown the clinical usefulness of training for voluntary muscle relaxation. Therefore, recent interest has centered in the application of electromyographic (EMG) feedback for the training of muscle relaxation. The EMG device accurately detects the level of tension in a muscle in terms of the number of microvolts sensed by skin surface electrodes. Feedback to the patient can be in the form of auditory and/or visual signals. While using the EMG feedback system, patients attain quicker and more thorough muscle relaxation than has been possible with the traditional relaxation techniques.

Biological feedback research programs have given evidence that indicate that other physiological functions, such as heart rate and blood pressure, can also be controlled voluntarily to some extent.

The doctor now wants to merge the results from these diverse biofeedback projects and develop a multi-sensor device capable of simultaneoulsy monitoring and displaying feedback information on a variety of physiologic measures, i.e., EKG, GSF, blood pressure, heart rate, EEG and EMG. A

monitor panel for the doctor's use would be equipped with a small analog computer which could be wired so as to have the capacity to indicate a patient's maximally reactive response to physiologic and psychologic stressors. The doctor believes that a multi-channel biofeedback device capable of functioning as described above would be of tremendous value to researchers and clinicians alike.

There are several commercial sources available for the purchase of the necessary biological electrodes, amplifiers, and analog signal conditioners. It is anticipated that the most difficulty will be with the analog computer. The doctor has considerable experience with biofeedback techniques and technology. However, he has no analog computer experience.

Therefore, the NASA technological contribution will be focused on assisting with the analog signal computer design and operation. Because the computer will be expected to perform complex calculations, there will be a tendency for the computer to become too bulky if commercial analog computers are used. In order to reduce the analog computer size, it is anticipated that some of the more complex modules of the computer will be fabricated from currently available integrated circuits.

PROBLEM STATUS: Continuing literature search.

PROBLEM MUSC-1

PROBLEM TITLE: "Survey of Quartz-Filled Composite Technology"
DATE OF PREPARATION: July 28, 1975
INSTITUTION: Medical University of South Carolina, College of Dental Medicine, Charleston, SC
DEPARTMENT: Biological and Physical Sciences
INVESTIGATOR: Dr. Robert A. Draughn, D.Sc.
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: A complete survey of NASA literature and technology centers for information concerning quartz-filled composite (plastic diacrylate matrix with quartz powder filler) materials.

HEALTH AREA: 17 REQUIREMENT: E

BACKGROUND: For many years, dentists have utilized an amalgum material of silver/tin/mercury for dental fillings for human teeth. Recently a new class of dental filling materials has been introduced. These materials are known as particulate composites. Usually, they are composed of a diacrylate plastic matrix containing powdered quartz as a filler. The dentist mixes the dental composite immediately before use by simply blending equal amounts of a premixed paste material from each of two dispenser vials. The composite paste sets within four minutes after mixing.

The typical composite filling is an opaque pearl color and blends very well with the color of the human tooth. There are dye kits available for use when the dentist wants to achieve a perfect color match between the tooth and the composite. The composite material also contains a small amount of Barium glass powder which makes the material opaque to X-rays.

At the present time, the use of composite material has been restricted to dental filling sites requiring cosmetic fillings. The reason for this limitation is that the composite fillings wear at a much more rapid rate than the amalgum fillings. The problem originator, a materials scientist, has established a research program to study the wear mechanisms for quartz-filled composite materials. He has requested help in surveying the NASA literature for articles (and laboratories) concerned with the testing and fabrication of quartz-filled composites for space applications. He feels certain that there are many pertinent contributions to composites science within the NASA literature that are not available in the open scientific literature. Once the wear mechanisms are understood, he feels that much more durable composites can be fabricated.

PROBLEM STATUS: An extensive literature search has been initiated.

PROBLEM MUSC-2

PROBLEM TITLE: "Verification of Vitreous Carbon Material for Use in Dental Implants"
DATE OF PREPARATION: July 29, 1975
INSTITUTION: Medical University of South Carolina
College of Dental Medicine
Charleston, SC
DEPARTMENT: Biological and Physical Sciences
INVESTIGATOR: Dr. Franklin A. Young, D.Sc.
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: A comprehensive survey of the basic physical and mechanical properties of vitreous carbon (glassy carbon) in order to judge its potential for use in fabrication of dental implants.

HEALTH AREA: 17 REQUIREMENT: E

BACKGROUND: Vitreous carbon offers promise as being a material which can be fabricated into dental implants. Research into the application of vitreous carbon to dental implants has only begun in the last two years. However, the problem originator believes that vitreous carbon, or glassy carbon, has not been studied closely enough concerning its basic physical and mechanical properties. Therefore, he has begun a project to carefully compile engineering data concerning the physical and mechanical properties of the pyrolytic carbon materials. He has requested a literature search of the NASA literature in order to compile enough of the basic engineering data on vitreous carbons to resolve existing conflicts of reported physical properties. Once the procedures for manufacturing vitreous carbons and for testing the physical properties of such pyrolytic carbons are agreed upon and standardized, the probability will be greater for the successful utilization of these materials in dental implants.

BIBLIOGRAPHY: "Development and Testing of a Vitreous Carbon Dental Implant," Grenable, D.E., et al, Proc. of the 18th National Society of Aerospace Material and Process Engineers Symposium, April 1973.
"Materials Science in Dental Implantation and a Promising New Material: Vitreous Carbon," J. A. vonFraunhofer, et. al., Bio-Medical Engineering, March 1974.

PROBLEM STATUS: A comprehensive literature survey has been initiated.

PROBLEM MUSC-3

PROBLEM TITLE: "Titanium Metal Sintering and Fabrication Techniques"
DATE OF PREPARATION: July 28, 1975
INSTITUTION: Medical University of South Carolina
College of Dental Medicine
Charleston, SC
DEPARTMENT: Biological and Physical Sciences
INVESTIGATOR: Dr. Franklin A. Young, D.Sc.
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: A review of the NASA technical literature to identify pertinent articles and personnel expertise in the technology of the titanium alloy sintering and metalworking.

HEATLH AREA: 17 REQUIREMENT: E

BACKGROUND: The problem originator is a materials scientist who is concerned with the fabrication of a dental implant, i.e., an artifical tooth root, which can be surgically buried in the human gum. The implant can serve as a structural support for dental bridgework after the implant becomes fixed in position in the gum due to tissue growth around the plant. Such implants must be entirely constructed of biologically inert material and also must have a surface texture which promotes intimate tissue growth about the implant. The tissue growth must be adequate so as to firmly affix the implant in the gum so that the implant can bear a load without loosening.

Pure A-70 titanium is machined to a conical shape to serve as the body of the implant. The exterior surface of the 8 mm long cone is covered with a monolayer of titanium alloy spheres approximately 300 microns in diameter (#80 mesh). The spheres are attached to the body of the implant by a sintering procedure at 1200°C in a neutral atmosphere.

Two models of the implant are being tested in adult dogs. One model has a threaded interior axial hole which exists on the 4 mm diameter base of the cone. The hole is sealed with a plastic plug until the time that bridgework is attached to the implant. The other model of the implant contains the abutment post as an integral part of the implant. The post, 2 mm wide in diameter and 6 mm long, is attached to the base of the conical implant.

The researcher believes that there is a considerable amount of information concerning titanium sintering and fabrication techniques within the NASA literature. He has requested help in surveying this literature and in eventually identifying personnel in NASA who may be a source of expertise in titanium metalworking.

OTHER COMMENTS: Please see attached scientific paper introduction for an enlarged photograph of the implants.

PROBLEM STATUS: Comprehensive literature search begun.

J BIOMED. MATER RES. SYMPOSIUM No 5 (Part 2), pp. 401-407 (1974)

Porous Titanium Dental Implants

F. A. YOUNG, *Medical University of South Carolina, Charleston, South Carolina 29401*

Summary

Titanium implants have been designed which utilize a solid core and porous exterior The technique for implants containing posts utilizes a cast chromium-cobalt splint for fixation and the buried implants are held in place by the overlying gingiva until tissue growth into the porosity results in stabilization

Clinically successful post implants with apparent bone ingrowth and healthy gingiva surrounding the posts have been achieved for periods up to three months.

C-10

INTRODUCTION

Able reviews of implant research to date have been conducted in several previous papers, and I will not attempt to repeat them. The aim of the research program, the results to date of which I will describe this morning, is to grow in place an anchor or artificial tooth root which can be made to serve as an abutment for either a crown or a bridge. The method chosen to accomplish this anchoring was based on the experience of the author [1] and the Clemson group [2] with porous calcium aluminate ceramics, which can be summarized by saying that viable tissue ingrowth can be obtained in totally buried implants, but that the problems of constructing a useable crown or bridge abutment from a weak, soluble, and rough surfaced material do not make this particular ceramic attractive. The search for an alternative material led us to consider metals as well as ceramics, and the apparent compatibility of titanium as well as our ability to process it easily into the desired shape led to initial trials of this metal These initial trials demonstrated that buried porous roots made by sintering titanium powder underwent the same types of tissue ingrowth as had the calcium aluminate ceramics [3]. It was, therefore, decided to investigate designs utilizing porous titanium as well as to attempt to find other useable ceramics. The research described today was an effort to find a practical technique and design using attachment to porous titanium.

MATERIALS AND DESIGN

It was desired to use spherical powder to minimize the surface area per unit volume of the porous portion of the implants. The only

spherical powder available at the commencement of these experiments was an alloy containing nominally 90% titanium, 6% aluminum, and 4% vanadium. The solid interior and post portions were made from commercially pure (A-70) titanium. This combination is undesirable from a galvanic couple point of view, however, no difficulties with corrosion have been experienced.

The root design selected was as simple and as representative of a natural tooth as could be easily fabricated –the truncated cone. Approximately 2 mm of porous powder was applied to the root of each implant by sintering at 1200°C in a neutral atmosphere. Two variations were used, one which contained a threaded hole, to be implanted and later reexposed for application of the abutment post, and one which contained a post integral with the solid titanium core. Both are illustrated in Figure 1. A cross section of a post implant is shown in Figure 2.

The experimental animals used were male canines approximately 1 year old. Initial experiments were conducted on mongrels and more recent implants have been placed in pedigreed beagles. These animals were selected because of their low cost, easy maintenance, and the ease of conducting operations in accessable sites.

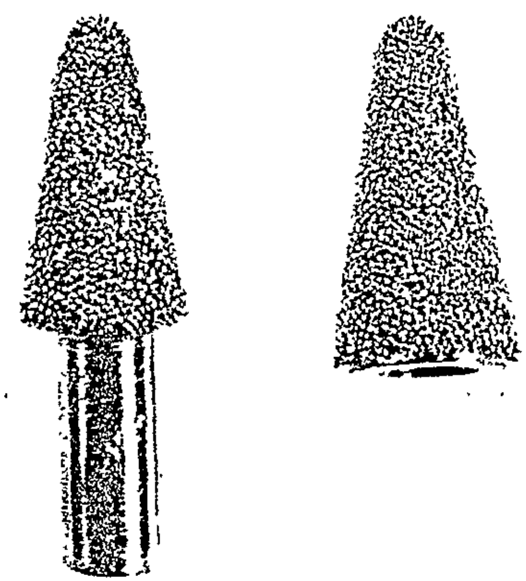

Fig. 1. Post and buried titanium implants.

PROBLEM UNC-88

PROBLEM TITLE: "Improved Cooling Technique"
DATE OF PREPARATION: August 18, 1975
INSTITUTION: University of North Carolina
DEPARTMENT: Surgery
INVESTIGATOR: Dr. Stanley R. Mandel
BATEAM PERSONNEL: Mr. R. W. Scearce

WHAT IS NEEDED: A technique is needed to provide longer cooling than provided by an equal volume of ice, but without excessive cost.

HEALTH AREA: 13 REQUIREMENT: E

BACKGROUND: Kidney transplant requires the careful matching of the donor with the recipient. Unfortunately the best matches are usually in different locations requiring the kidney to be transported over long distances. Available transporters keep the kidney at +4°C by closely regulating the temperature of the perfusate. Cooling is provided by ice. While most kidneys make the journey successfully, some are lost when ice runs out and the perfusate temperature increases well above the desired 4°C. If a material was available that provided longer cooling than ice, this problem could be eliminated.

The existing transporters have an insulated container approximately 10 inches high and 4 inches square in which the ice is placed. An antifreeze is circulated through coils contained in this ice container. The antifreeze is then pumped through a heat exchanger to cool the perfusate. Flow of the antifreeze is regulated to maintain the desired perfusate temperature. The difficulty arises when the ice completely melts without any replacement.

CONSTRAINTS AND SPECIFICATIONS: Material must be readily available, cheap and easy to handle. It must be adaptable to the cooling system of a kidney transporter and provide for longer cooling of the perfusate than presently provided by ice.

PROBLEM STATUS: Evaluating possible solution from Ames Research Center.

PROBLEM UNC-89

PROBLEM TITLE: "Protein Separation"
DATE OF PREPARATION: August 18, 1975
INSTITUTION: University of North Carolina
DEPARTMENT: Medicine
INVESTIGATOR: Dr. Judson J. Vanwyk
BATEAM PERSONNEL: Mr. R. W. Scearce

WHAT IS NEEDED: A technique is needed to separate several proteins which all have very similar electrical mobility constants.

HEALTH AREA: 18 REQUIREMENT: A

BACKGROUND: Growth hormone, until recently, was believed to act at many sites throughout the body--making it the only hormone not having a specific target organ. Research has shown that it does, in reality, have a target organ, the liver, where it causes the production of another material (Somatomedian) which actually exerts the growth effect. This new material was discovered and named by the problem originator. He is now attempting to identify and produce Somatomedian, but cannot achieve the desired separation of the many proteins. He asked if NASA was using a new technique called isotachophoresis. If they were, could they suggest any way of solving this problem.

CONSTRAINTS AND SPECIFICATIONS: A technique is needed which will provide better separation of proteins than standard electrophoresis.

PROBLEM STATUS: Evaluating suggestion from Marshall Space Flight Center to use isotachophoresis.

PROBLEM WF-121

PROBLEM TITLE: "Accurate Measurement of Input and Output Power From Ultrasonic Probes"
DATE OF PREPARATION: August 15, 1975
INSTITUTION: Bowman-Gray School of Medicine
DEPARTMENT: Medicine
INVESTIGATOR: Dr. Fred Kremkau
BATEAM PERSONNEL: Dr. H. Clark Beall

WHAT IS NEEDED: A survey of NASA literature and technology on ultrasound applications in order to determine the most accurate methods of measuring RF input power to a ultrasonic probe and of measuring ultrasound power within the test material.

HEATLH AREA: 2 REQUIREMENT: F

BACKGROUND: Most commercial and industrial efforts in ultrasound medical instrumentation are directed toward utilizing ultrasound as a clinical diagnostic tool for imaging internal body structures. However, the more intense ultrasound can damage biological tissue. There is therefore a comparison to the situation with X-rays...at low intensities, the technology is useful for diagnosis, and at high intensities the technology is useful for clinical cure because of the localized tissue damage the radiation inflicts. Thus, there is consequently some risk of biological tissue damage when using ultrasound instruments for diagnosis.

The problem originator's laboratory is one of only a half dozen laboratories in the U.S.A. specializing in the study of biological tissue damage from ultrasound. Such research must be completed before the hazards of ultrasound can be assessed. When the assessment is complete, safety standards can be established for the diagnostic use of ultrasound. Also, the value of utilizing ultrasound as a clinical cure can be evaluated.

Due to the fact that medical ultrasound ranges from 1 MHz to 10 MHz, there are difficulties in achieving good matching impedances between various ultrasonic probes and the biological tissue under test in the research lab. The lack of match in impedances contributes to ambiguity of measurement of ultrasonic field power within the test material. Also, there are difficulties in evaluating the electric field of the radiofrequency which drives the probe. Standing wave meters are available which should measure reflected power in the amplifier/probe circuit. But the meters have large variances at different frequencies in their passband. If large percentages of reflected power is present, there is large error in the meter because the meter is designed to operate at low SWR.

The problem originator would like a survey of the NASA technology on ultrasound topics with particular emphasis on 1) the accurate measurement of ultrasonic probe input power, by SWR meters or otherwise, and 2) the accurate

measurement of the power intensity of the ultrasonic field within test material such as biological tissues. By the time the literature search has been completed, personnel at NASA field centers working with ultrasound will have been identified so that personal communications between them and the researcher can be established.

PROBLEM STATUS: Literature search initiated.